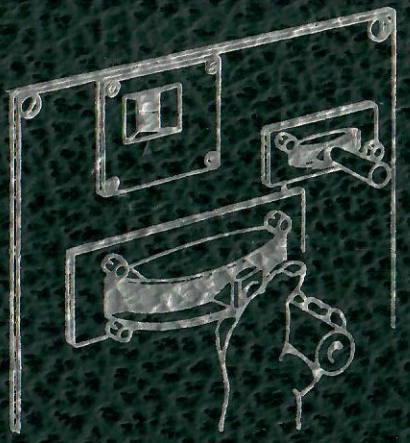

# SD45

# OPERATOR'S MANUAL

Electro-Motive Division
La Grange, Illinois

GM

# SD45
# OPERATOR'S
# MANUAL

GENERAL MOTORS
LOCOMOTIVES

4th Edition
February, 1968

SERVICE DEPARTMENT

ELECTRO-MOTIVE DIVISION
GENERAL MOTORS CORPORATION
LA GRANGE, ILLINOIS, U.S.A.

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## NOTICE

The data appearing in this manual is intended as a guide and as an aid in explaining the locomotive equipment used during operation. It is generally applicable to a basic locomotive, that is, a locomotive without optional extra equipment. Some data is also included for a number of the more frequently used extras. When special extra equipment is involved, consult specific drawings or instructions as provided by the railroad.

The information contained in this manual is based on data available when released for printing.

Minor differences encountered in equipment are due to changes made after the manual was sent to press. These changes will be covered in subsequent editions of this manual.

## INTRODUCTION

This manual has been prepared to serve as a guide to railroad personnel engaged in the operation of the 3600 horsepower General Motors Model SD45 turbocharged diesel-electric locomotive.

The contents are divided into four sections as follows:

1. General Description - Provides general description of principal equipment components.

2. Cab Controls - Explains functions of cab control equipment used in operating the locomotive.

3. Operation - Outlines procedures for operation of the locomotive.

4. Trouble Shooting - Describes cause, location and correction of possible troubles occurring during operation.

A block of page numbers is allocated to each section, Section 1 starting with page 101, Section 2 with 201 and the others following in this manner. Figures are identified by section and sequence. For example: Fig. 2-3 is the third figure used in Section 2.

To obtain the most benefit from this manual, it is recommended that the sections be read in the sequence in which they appear.

Information pertaining to maintenance, adjustment, and testing is contained in the Locomotive Service Manual. Instructions for testing and maintenance of individual locomotive components will remain a part of the standard EMD Maintenance Instruction bulletin series.

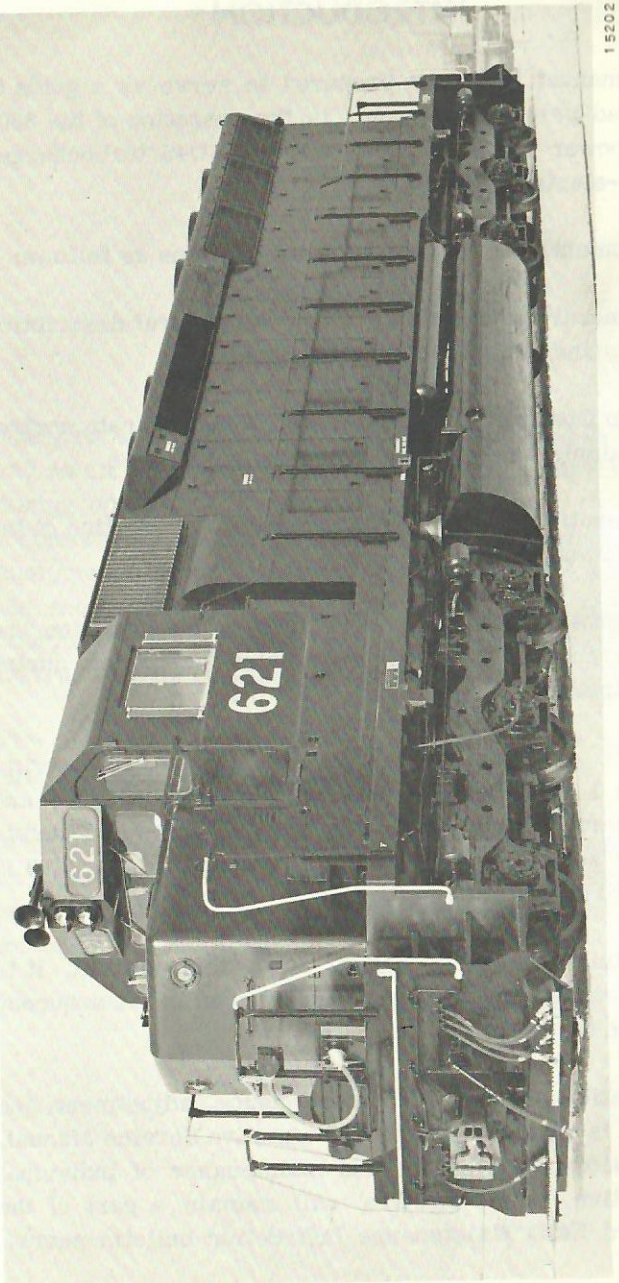


Fig. 0-1 — SD45 Locomotive



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## GENERAL DATA

| | |
|---|---|
| Model Designation | SD45 |
| Locomotive Type | (C-C) 0660 |
| Locomotive Horsepower | 3600 |
| **Diesel Engine** | |
| Model | 645E3 |
| Number Of Cylinders | 20 |
| Cylinder Arrangement | 45° "V" |
| Cylinder Bore And Stroke | 9-1/16" × 10" |
| Operating Principle | 2 Stroke Cycle, Turbocharged, Unit Injection, Water Cooled |
| Full Speed | 900 RPM |
| Idle Speed | 315 RPM |
| Main Generator Model | AR10 - D14 |
| Traction Alternator (Rectified Output) | AR10B |
| Number Of Poles | 10 |
| Nominal Voltage (DC) | 600 |
| Frequency (at 900 RPM) | 75 cps |
| Companion Alternator | D14 |
| Nominal Voltage (AC) | 180 |
| Number Of Poles | 16 |
| Frequency (At 900 RPM) | 120 cps |
| **Auxiliary Generator** | |
| Voltage (DC) | 74 |
| Rating | 10 KW |
| **Traction Motors** | |
| Model | D77 |
| Number | 6 |
| Type | DC, Series Wound, Axle Hung |
| **Driving Wheels** | |
| Number | 6 Pair |
| Diameter | 40" |
| Tread | Tapered |

Maximum Speed Options With Gear Ratio And Continuous Ratings

| Gear Ratio | Top Speed MPH | Continuous Drag MPH |
|---|---|---|
| 62:15 | 71 | 11.3 |
| 61:16 | 77 | 12.2 |
| 60:17 | 83 | 13.2 |

Air Compressor
- Type . . . . . 2 Stage
- Number Of Cylinders . . . . . 3
- Capacity (At 900 RPM) . . . . . 254 Cu. Ft./Min.
- Air Compressor Cooling . . . . . Water
- Lube Oil Capacity . . . . . 10-1/2 Gal.

Storage Battery
- Number Of Cells . . . . . 32
- Voltage . . . . . 64
- Rating (8 Hour) . . . . . 420 Amp Hr.

Supplies
- Lubricating Oil Capacity . . . . . 294 Gal.
- With Deep Sump Oil Pan . . . . . 467 Gal.
- Cooling Water Capacity . . . . . 288 Gal.
- Fuel Capacity (Basic) . . . . . 3200 Gal.
- With Extra Capacity . . . . . 4000 Gal.
- Sand . . . . . 56 Cu. Ft.

Air Brakes . . . . . Type 26L

Approximate Weight On Rails . . . . . 368,000 lbs.

Weight On Drivers . . . . . 100%

Major Dimensions
- Length Between Coupler Faces . . . . . 65' 8"
- Width Over Underframe . . . . . 10'
- Overall Height - Top Of Rail To Top Of Cooling Fan . . . 15' 7-3/16"

Minimum Curve Radius
- Single Unit . . . . . 193'
- Coupled To Standard 50 Ft. Car . . . . . 338'





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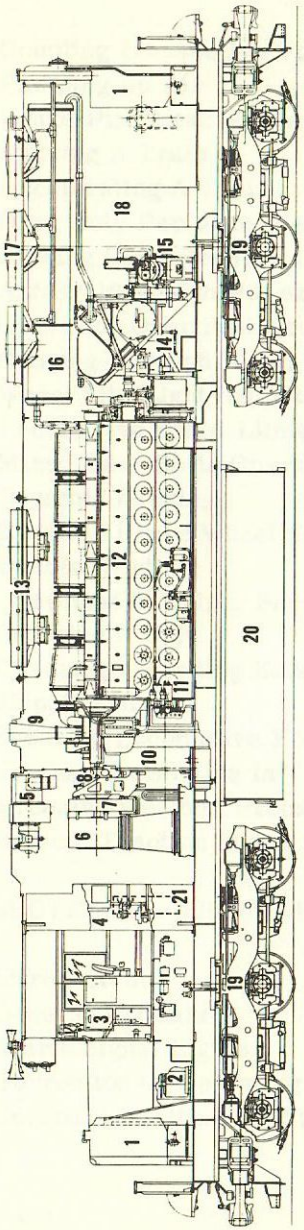



1. Sand Box
2. Battery
3. Control Stand
4. No. 1 Electrical Cabinet
5. Inertial Air Filter
6. Traction Motor Blower
7. Generator Blower
8. Auxiliary Generator
9. Turbocharger
10. Main Generator
11. Engine Cranking Motors
12. Engine 20-645E3
13. Dynamic Brake Fans
14. Equipment Rack
15. Air Compressor
16. Radiators
17. Radiator Cooling Fans
18. No. 2 Electrical Cabinet
19. Trucks
20. Fuel Tank
21. Electrical Cabinet Air Filter

Fig. 1-1 — General Arrangement — SD45 Locomotive



# SECTION 1

# GENERAL DESCRIPTION

## INTRODUCTION

The General Motors Model SD45 locomotive, illustrated in Fig. 1-1, is equipped with a turbocharged diesel engine that delivers 3600 horsepower to the main generator for tractive purposes. This power is then distributed to six traction motors, each of which is directly geared to a pair of driving wheels.

The basic locomotive is arranged and equipped so that the short hood or cab end is considered the front or forward part of the unit. However, the locomotive operates equally well in either direction, and on special order controls may be arranged so that the long hood end is forward, or dual controls may be provided.

The locomotive may consist of one or more individual units, each of which is a completely functional power plant. When coupled together for multiple unit operation, all can be simultaneously controlled from a single set of controls located in the cab of the lead unit. This is accomplished through jumper cables connected between the units.

The general arrangement of equipment used on the SD45 locomotive is shown in Fig. 1-1. Each of the more important equipment components is numbered and identified in this illustration.

## HOW THE LOCOMOTIVE OPERATES

1. The fuel pump is driven by an electric motor which, for fuel priming, uses current from the storage battery. Once the engine is started and running,

the fuel pump motor uses current directly from the auxiliary generator. The fuel pump transfers fuel from the fuel tank under the locomotive to the engine injectors.

2. The diesel engine is started by means of two series connected 32-volt cranking motors that engage the flywheel ring gear when starting current is applied. The storage battery supplies electric current to engage the starting pinions and rotate the cranking motors.

3. When the engine is running, it supplies mechanical power through shafts and couplings to directly drive three electrical generators, the air compressor, motor and generator blowers, and engine mounted lube oil and cooling water pumps.

4. The auxiliary generator charges the storage battery and supplies low voltage direct current for the control and lighting circuits. The companion alternating current generator furnishes power to the static exciter, various transductors, the three radiator cooling fans, and the inertial separator blower motor. The main traction alternator supplies high voltage AC to a power rectifier assembly which then delivers high voltage DC to the traction motors for locomotive pulling power.

5. By means of the cab controls, low voltage circuits are established to actuate the engine governor and the switchgear in electrical cabinets. This switchgear controls generator excitation and distribution of power.

6. Six traction motors are located under the locomotive. Each traction motor is directly geared to an axle and pair of driving wheels. These motors are





located in two trucks which support the locomotive weight and distribute it to the driving wheels.

7. The throttle electrically controls speed and power by actuating a governor mounted on the engine and by tying the response of the locomotive power control system to throttle position. The main generator converts the engine's mechanical power to electrical power, which is then distributed to the traction motors through circuits established by the various switchgear components in the electrical cabinet.

8. At locomotive start the throttle controls electrical devices that provide rapid power response at a level consistent with smoothly controlled starting.

9. During heavy-drag low-speed operation, electrical devices operating within adhesion considerations control power at an optimum level consistent with the capabilities of less powerful locomotives that may be in a consist.

10. At moderate and high operating speeds a load regulator operates to maintain power output at the specific level called for by throttle position. This prevents the engine from being overloaded or underloaded.

11. The air compressor supplies, to the reservoirs, air under pressure used primarily for the air brakes. The air brakes are controlled by the operator through suitable equipment in the cab.

12. Except for manual operation of the cab controls, the locomotive operation is completely automatic. Various alarms and safety devices will alert the operator should any operating difficulties occur.

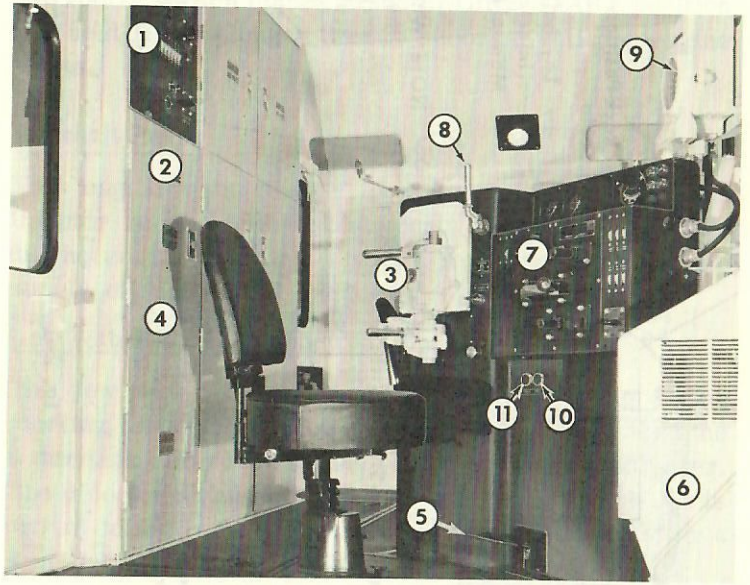
# SECTION 2

# ENGINE STARTING AND CAB CONTROLS

## INTRODUCTION

A switch for fuel priming and engine cranking is located at the equipment rack in the engineroom. All other basic control equipment used during locomotive operation is at five locations within the cab, Fig. 2-0.

1. The Switch And Fuse Panel
2. Circuit Breaker Panel
3. The Engine Control Panel
4. The Locomotive Control Stand
5. The Air Brake Pedestal

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1. Engine Control Panel
2. Circuit Breaker Panel
3. Air Brake Controls
4. Switch And Fuse Panel
5. Safety Control Pedal
6. Cab Heater
7. Locomotive Controller
8. Air Horn Lever
9. Speed Recorder
10. Ground Reset Button
11. Attendant Call Button

Fig. 2-0 — Locomotive Control Station

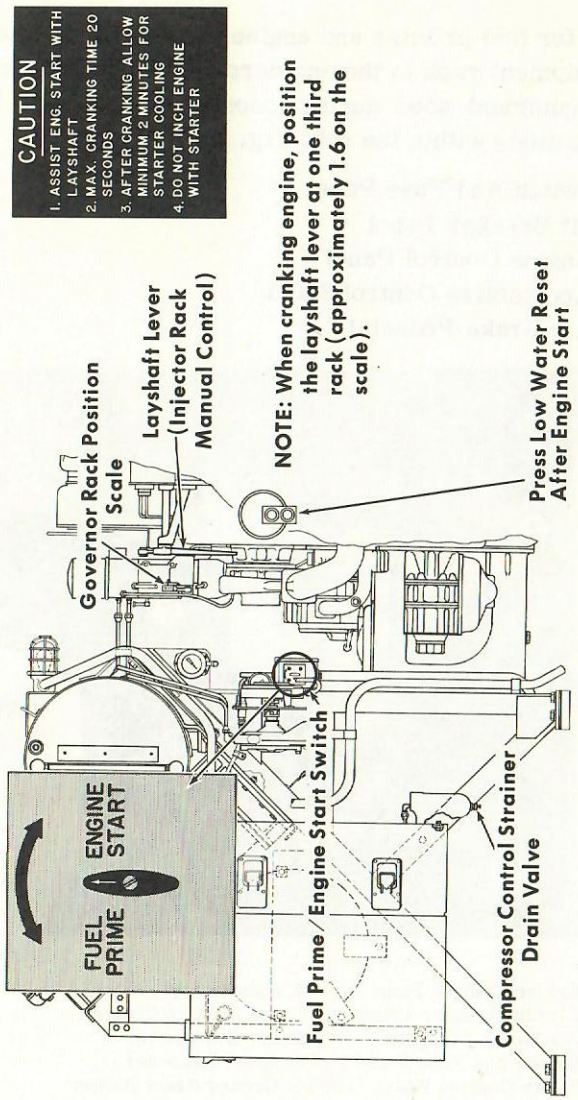

CAUTION
1. ASSIST ENG. START WITH LAYSHAFT
2. MAX. CRANKING TIME 20 SECONDS
3. AFTER CRANKING ALLOW MINIMUM 2 MINUTES FOR STARTER COOLING
4. DO NOT INCH ENGINE WITH STARTER
Governor Rack Position Scale
Layshaft Lever (Injector Rack Manual Control)
NOTE: When cranking engine, position the layshaft lever at one third rack (approximately 1.6 on the scale).
Press Low Water Reset After Engine Start
ENGINE START
FUEL PRIME
Fuel Prime / Engine Start Switch
Compressor Control Strainer Drain Valve
14918

Fig. 2-1 — Engine Starting Controls





## ENGINE STARTING CONTROLS, FIG. 2-1

### Fuel Prime And Engine Start Switch

This switch, located on the equipment rack in the engine-room, is a three-position rotary switch used for fuel priming and engine starting. Before attempting to start the diesel engine, the isolation switch in the locomotive cab must be placed in the START position. The rotary switch must then be placed in the FUEL PRIME position and held there for 10 to 15 seconds to operate the fuel pump. The layshaft lever must then be positioned and the rotary switch placed in the ENGINE START position and held (for no longer than 20 seconds) until the engine starts.

### Layshaft Lever

This engine mounted hand operated lever operates the injector racks. It is used to position the injector racks during engine cranking, thereby providing an immediate supply of fuel to the cylinders.

### Low Water Reset Pushbutton

The low water detector will often trip during engine starting, especially when the engine is cold or when the water tank pressure cap has been removed to add water. The detector should be reset as soon as the engine starts and is idling, or else the engine will shut down after a time delay established by the governor.

Check the low water reset pushbutton after every engine start.

NOTE: The reset buttons on some detectors will not latch in when the engine is shut down. If such a condition is encountered, reset the device after engine start.

## SWITCH AND FUSE PANEL

The panel shown in Fig. 2-2 is located within the electrical cabinet that forms the rear wall of the locomotive cab. Its position is directly below the engine control panel which is located in the upper left hand corner of the electrical cabinet.

### Battery Charging Fuse And Receptacle

As a modification when requested by the railroad, provision is made at the switch and fuse panel for connection of an external source of DC power to charge the locomotive battery. The battery charging fuse is provided to protect the charging circuit.

### Electric Toilet Fuses

These fuses are provided on locomotives equipped with an electric incinerating toilet.

### D14 Alternator Field 60-ampere Fuse

The D14 alternator receives its excitation through a pair of slip rings connected to the low voltage DC auxiliary generator output. To protect these windings, a 60-ampere fuse is provided in the excitation circuit. This fuse must be good and in place at all times during locomotive operation.

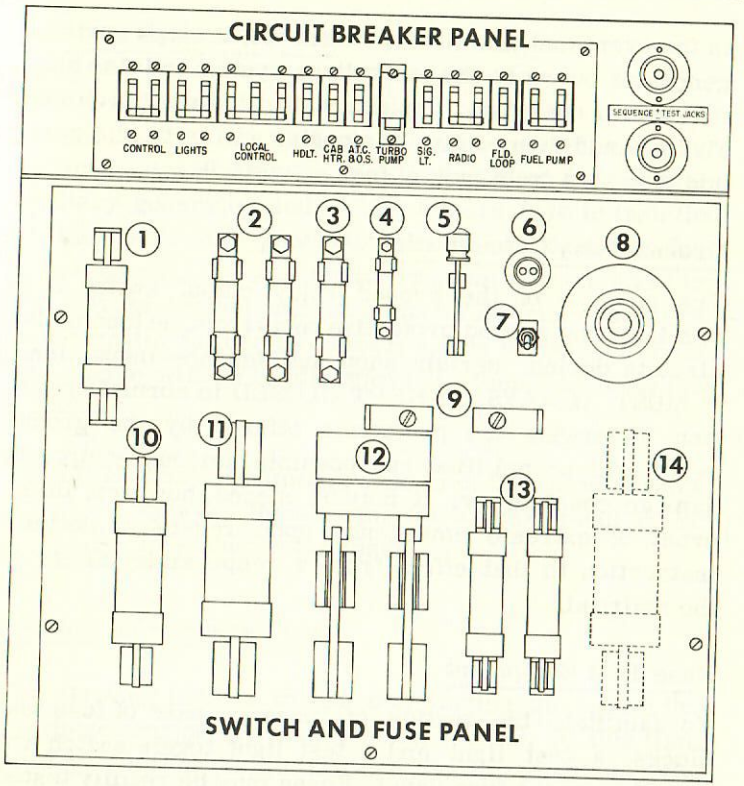
In the event that the fuse is blown, D14 alternator excitation and resulting power output will cease, setting off the no power alarm, and reducing the engine speed to idle.

### Auxiliary Generator Field 30-ampere Fuse

The field excitation circuit of the auxiliary generator is protected by a 30-ampere fuse. This fuse must be good and in place at all times during locomotive operation.








14009

* 1. Battery Charging Fuse
* 2. Electric Toilet Fuses
3. D14 Alternator Field 60 Amp Fuse
4. Auxiliary Generator Field 30 Amp Fuse
5. Ground Relay Cutout Switch
6. Fuse Test Light
7. Fuse Test Light Switch
* 8. Battery Charging Receptacle
9. Fuse Test Terminals
10. Auxiliary Generator 150 Amp Fuse
11. Starting 400 Amp Fuse
12. Main Battery Knife Switch
13. Main Generator Field 100 Amp Fuses
*14. Auxiliary Generator 250 Amp Fuse (With 18 KW Aux. Generator)

*Indicates Extra Modifications

Fig. 2-2 — Circuit Breaker Panel, And Switch And Fuse Panel

In the event that this fuse is burned out, it stops auxiliary generator output to the low voltage system and also stops fuel pump operation. An alternator failure (no power) alarm would then occur. The engine will go to idle speed and then stop from lack of fuel.

### Ground Relay Cutout Switch

The purpose of the ground relay cutout switch is to eliminate the ground protective relay from the locomotive circuits during certain shop maintenance inspections. It MUST ALWAYS BE KEPT CLOSED in normal operation, otherwise the protection offered by the ground relay will be nullified and possible serious equipment damage could occur. It may be opened, however, in the event of extreme emergency upon receipt of definite instruction to that effect from a responsible officer of the railroad.

### Fuse Test Equipment

To facilitate the testing of fuses, a pair of fuse test blocks, a test light and a test light toggle switch are installed on the fuse panel. Fuses may be readily tested as follows. First, move the toggle switch to the ON position to make sure the fuse test light is not burned out. Extinguish the light by moving the toggle switch to the OFF position. Place a fuse across the test blocks so that the metal ends of the fuse are in firm contact with the blocks. If the fuse is good, the light will come on. If the fuse is burned out, the light will not come on and a new fuse is required.

It is always advisable to test fuses before installing them in their circuits. Always isolate the circuits in question by opening their switches before changing or replacing fuses.





### Auxiliary Generator Fuse

This fuse connects the auxiliary generator to the low voltage system. It protects against excessive current demands. A 150 ampere fuse is installed for the basic auxiliary generator and a 250 ampere fuse is installed for the heavy duty generator. In the event that the fuse is burned out, it stops auxiliary generator output to the low voltage system and also stops fuel pump operation. An alternator failure (no power) alarm would then occur. The engine will go to idle speed and then stop from lack of fuel.

CAUTION: The 250 ampere fuse is of the same physical size as the starting 400 ampere fuse. Do not interchange the fuses.

### Starting 400-ampere Fuse

The starting fuse is in use only during the period that the diesel engine is actually being started. At this time, battery current flows through the fuse and starting contactor to the cranking motors.

Although this fuse should be in good condition and always left in place, it has no effect on locomotive operation other than for engine starting. A defective fuse can be detected when attempting to start the engine, since at that time (even though the starting contactors close) the cranking circuit is open.

### Main Battery Knife Switch

The large double-pole single-throw knife switch at the lower portion of the fuse panel is the main battery switch.

It is used to connect the battery to the locomotive low voltage system and should be kept closed at all times during operation.

If this switch were left open, the fuel pump could not be started, the lights would not function and the engine could not be started. If the switch is opened after the engine has been started, the auxiliary generator will continue to supply the low voltage needs, but the batteries will not receive charge.

This switch may be opened during certain shop maintenance procedures and in instances where the engine is shut down and the locomotive taken out of service for an extended layover. This will prevent the battery from being discharged in the event the lights or other low voltage devices are inadvertently left operating during the layover. Particular attention should be given when a notation at the switch cautions against opening the switch immediately after engine shutdown. At least 35 minutes should be allowed following engine shutdown before this switch is opened after load operation at or above throttle position No. 3. That is, cooldown time for the turbocharger bearings can be considered to accumulate below throttle position No. 3 even though the 35 minute timing of the turbocharger auxiliary lube oil pump begins at engine shutdown.

AR10 Generator Field 100-ampere Fuses

The AR10 generator receives its excitation through a pair of slip rings connected to the D14 alternator output through a controlled rectifier. The fuses are provided to protect the controlled rectifier and the generator field windings. A single blown fuse may cause a loss of dynamic braking but no detectable loss of power. Two





blown fuses will result in a complete loss of power. Be certain to test these fuses every time they are removed and reinstalled.

## CIRCUIT BREAKER PANEL

This panel is located above and forward of the switch and fuse panel, but behind the same cabinet door. It contains the following equipment.

Control 40-ampere Circuit Breaker

This circuit breaker must be in the ON position before locomotive operation is possible. It sets up the fuel pump and control circuits for engine starting. Once the engine is running, power is supplied through this breaker from the auxiliary generator to maintain operating control.

Lights 30-ampere Circuit Breaker

This circuit breaker must be ON to supply power for the individual switches provided for platform, engine room and identification lights.

Local Control 30-ampere Circuit Breaker

This circuit breaker must be in the ON position before operation of the locomotive is possible. During operation it establishes "local" power from the auxiliary generator to operate heavy duty switchgear, and various control devices.

Turbo Pump Motor 30-ampere Circuit Breaker

This circuit breaker must be in the ON position to start the engine and operate the turbocharger auxiliary lube oil

pump. It must remain in the ON position to provide auxiliary lubrication to the turbocharger at engine start and after the engine is shut down. A guard is provided over this breaker switch to prevent accidental movement to the OFF position.

### Miscellaneous Circuit Breakers

These breakers can include one each for the headlight, automatic train control, overspeed switch, cab heater, radio, signal light, and field loop if applicable. The circuit breakers should be placed in the ON position to obtain the desired operation.

### Fuel Pump Circuit Breaker

The fuel pump circuit breaker must be ON for normal operation.

### Test Jacks

The cabinet mounted test jacks are located in the high voltage system. When telephone plugs or 7/32" metal rods are inserted in the jacks, various relay voltage coils are disconnected from the main generator. This enables calibration of circuits through the use of a fixed voltage from an MG set.

CAUTION: High voltage is present at the test jacks during locomotive operation.

## ENGINE CONTROL PANEL

The engine control panel, Fig. 2-3, is located at the upper left hand corner of the electrical cabinet that forms the rear wall of the cab. This panel contains various switches and alarm lights, along with a battery charging meter or light. Since all of these items will be used at





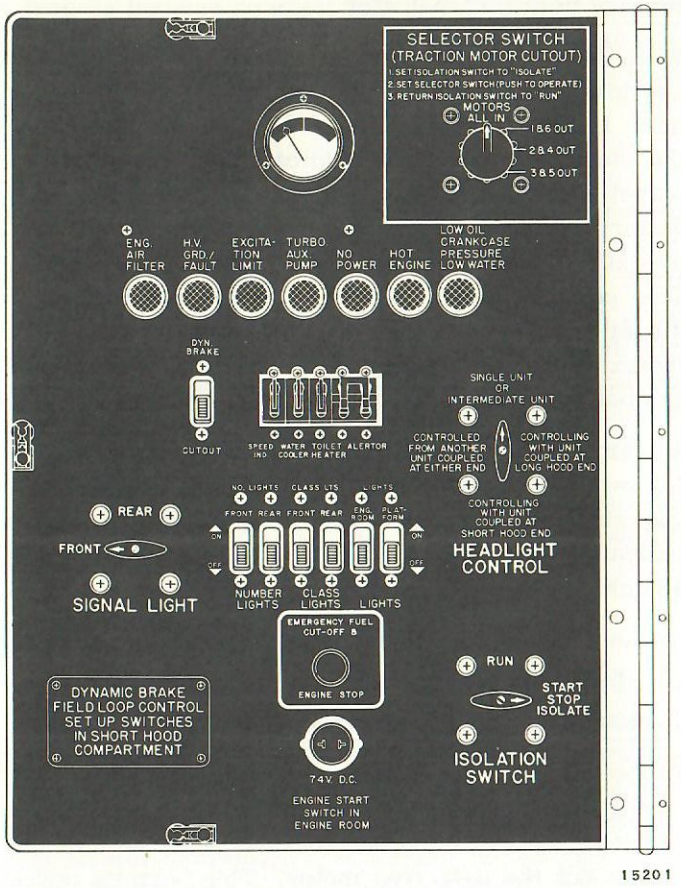



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Fig. 2-3 — Engine Control Panel With Typical Extras

one time or another during operation, a brief description of their individual functions is provided.

Note that an alarm bell accompanies alarm signal light indications. The bell will ring in all units of a locomotive consist, but the light will come on only in the affected unit.

### Battery Charging Indicator

With the main battery knife switch closed, the battery charging indicator is connected into the low voltage circuits to indicate the extent of current flowing to or from the storage battery. This indicator does not indicate the output of the auxiliary generator. Since the storage battery is usually well charged, the indicator in normal operation should read zero or slightly in the green area. The pointer should never be in the red area with the diesel engine running, even at idle speed. Such a reading indicates that the battery is discharging, which if allowed to continue could lead to failure of the locomotive unit.

A very strong discharge at time of engine shutdown, followed by blown fuses, indicates a shorted battery charging rectifier. When a very strong discharge is indicated, exercise care before opening the main battery switch.

As an extra modification, a battery charging light may be applied in lieu of the indicator.

### Remote Traction Motor Cutout Switch (If Provided)

In the event of a defective traction motor, the traction motor cutout switch can be operated (provided the unit is isolated and the local control circuit breaker is closed) to cut out the defective motor. This permits operation with four motors. The power control system automatically limits power to prevent overloading the operative motors.

### Engine Air Filter Light

On units equipped with pleated paper engine air filters, a pressure sensitive switch is connected to sense air pressure drop across the locomotive inertial air filter plus the paper filters. When dirt in the filters causes





the drop to become so great that power may be lost and the possibility of turbocharger overheating exists, the pressure switch closes to energize a latching relay and turn on the air filter light.

### H.V. GRD / FAULT Light

The light indicates that an electrical path to ground has occurred, or that a group of five diodes in the main generator has failed. When the light comes on and the alarm sounds, the operator should wait 10 seconds, then press the ground reset button located on the control stand, Fig. 2-5, and proceed with normal operation. The routine procedure established by the railroad should be used to report the light indication and the alarm.

When the alarm rings for the third time after using the ground reset button twice, the affected unit should be isolated.

### Excitation Limit Light

An electrical system relates generator excitation to main generator output and acts to hold power at an acceptable level during various temporary conditions of locomotive operation. Should this system lose calibration or somehow fail, there would be no protection against abnormally high generator current.

An excitation limit relay senses high generator field current and acts to modulate it. When this action occurs, generator current and voltage are held to acceptable values.

The excitation limit condition is normally temporary and no action is required by the operator; however, if the condition persists, the green excitation limit light comes on, a timing relay drops generator excitation and locks in the excitation limit circuit.

Power can be recovered if the throttle is returned to idle position and reopened. However, if the excitation limit light locks on again, the unit should be isolated.

### Turbocharger Auxiliary Pump Motor Light

This light will come on as soon as the main battery switch and turbo lube pump circuit breaker are closed. It indicates that the turbocharger auxiliary lube oil pump is supplying lube oil to the turbocharger. It will remain on for approximately 35 minutes after the main battery switch is closed. When the fuel prime engine start switch is operated after the 35 minute period, the time cycle is again re-established and the light remains on for another 35 minutes.

The light will also come on and remain on for approximately 35 minutes after the engine is stopped to provide an indication that the auxiliary lube oil pump is supplying oil to cool the turbocharger bearings.

### No Power Alarm Light

The no power light (blue) will come on, and the alarm bell will ring any time the no AC voltage relay (NVR) opens with the isolation switch in RUN position and the ER switch in ON position. This will occur if the engine stops for any reason or if D14 alternator failure occurs during operation.

### Low Oil/Crankcase (Oil Pan) Pressure/Low Water Alarm Light

A mechanism to detect low engine lubricating oil pressure or high suction is built into the engine governor. This mechanism is actuated by true oil pressure failure





or by dumping oil from the engine oil line leading to the governor. In either event a small button will pop out of the governor body, indicating that the mechanism has tripped the low oil alarm switch. The amber light on the engine control panel will come on to indicate that the low oil mechanism has tripped.

When a Crankcase (Oil Pan) Pressure/Low Water/Low Oil alarm occurs it is necessary to determine whether the crankcase pressure - low water detector has tripped to dump engine oil from the line leading to the governor, or whether a true oil failure has occurred. This can be determined by checking the crankcase pressure - low water detecting device, Fig. 3-2, for protruding reset buttons. A protruding upper button indicates excessive oil pan pressure; a protruding lower button indicates low water.

NOTE: The reset buttons on some detectors will not latch in while the engine is shut down, and on some detectors the button will trip at engine start. Always check and press the reset button immediately after starting the engine.

### Hot Engine Alarm Light

The hot engine alarm light (red) operates in conjunction with the alarm bell to warn the operator that the engine cooling water has reached an excessive temperature.

### Miscellaneous Switches

Switches are included in circuits for various lights and devices on the locomotive. The switches are closed as desired to operate the class lights, the number lights, the engine room lights, and the platform lights.

## Headlight Control Switch

The twin sealed-beam front and rear headlights are controlled by the front and rear headlight switches on the locomotive control panel. A dimming switch is mounted on the right side of the controller. Before these switches will function, the 30-ampere headlight circuit breaker must be placed ON.

On locomotives equipped for multiple unit operation, a remote headlight control switch is mounted on the engine control panel. This remote headlight control switch provides for operation of the rear unit headlight from the lead unit. The switch positions are set on each unit as follows:

1. On Lead Unit

   If only a single locomotive unit is being used, place the switch in SINGLE UNIT position.

   In multiple unit service, if trailing units are coupled to the No. 2 or long hood end of the lead unit, place the switch in the CONTROLLING - COUPLED AT LONG HOOD END position.

   In multiple unit service, if trailing units are coupled to the No. 1 or short hood end of the lead unit, place switch in CONTROLLING - COUPLED AT SHORT HOOD END position.

2. On Intermediate Units

   On units operating in between other units in a multiple unit consist, place the switch in the SINGLE UNIT position.





3. On Trailing Units

   The last unit in a multiple unit consist should have the headlight control switch placed in the CONTROLLED - COUPLED AT EITHER END position.

## Unit Selector Switch, Fig. 2-4

The unit selector switch (if provided) is located in the short hood compartment of the locomotive. It is used only on locomotives equipped with dynamic brakes and a field loop circuit. Its purpose is to adjust circuit resistance for uniform dynamic brake operation.

This switch should be set to the No. 1, 2, 3 or 4 position, depending on the number of locomotive units physically and electrically connected together. The switch position should not be changed for any reason other than to correspond to a change in number of units being operated. For example, it should not be changed if one of the units is isolated or shut down while it remains in the locomotive consist.

This switch position is of importance only in the lead or controlling locomotive unit during operation in dynamic braking. It has no function in intermediate or trailing units.

NOTE: Switch position may be changed only while the throttle is in IDLE or locomotive is at rest. It should never be moved while operating in dynamic braking.

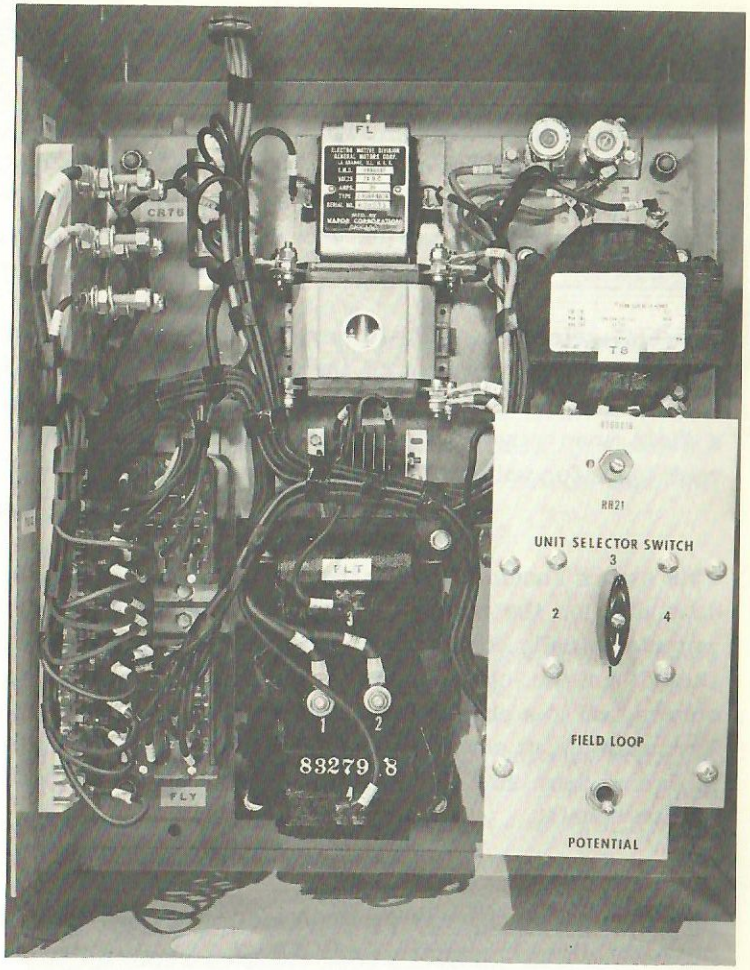


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Fig. 2-4 — Field Loop Control Panel

## Emergency Fuel Cutoff And Engine Stop Pushbutton

The switch on the engine control panel is wired in series with emergency fuel cutoff switches located at the fuel filler openings. Pressing any one of the pushbuttons will





cause the engine stop immediately. The switches are spring loaded and do not need to be reset.

CAUTION: The main battery switch and the turbocharger circuit breaker must remain closed for 35 minutes when the engine stops after load operation at throttle position No. 3 or higher.

## Engine Start Switch Legend

The fuel prime/engine start switch is located on the equipment rack in the engineroom, see Fig. 2-1. This location allows the operator to manipulate the engine layshaft lever during engine cranking, thereby facilitating faster starting with less drain on the locomotive battery.

## Isolation Switch

The isolation switch has two positions, one labeled START / STOP / ISOLATE, the other labeled RUN. The functions of these two positions are as follows:

1. START / STOP / ISOLATE Position

The isolation switch is placed in this position whenever the diesel engine is to be started. The start switch is effective only when the isolation switch is in this position.

The START position is also used to isolate the unit, and when isolated the unit will not develop power or respond to the controls. In this event the engine will run at idle speed regardless of throttle position. This

position will also silence the alarm bell in the event of an excitation limit, a ground relay, a no power, or a low lube oil alarm. It will not, however, stop the alarm in the event of a hot engine.

If the locomotive is equipped with remote traction motor cutout switch, the isolation switch must be placed in the ISOLATE position before the cutout switch can be operated.

2. RUN Position

After the engine has been started, the unit can be placed "on the line" by moving the isolation switch to the RUN position. The unit will then respond to control and will develop power in normal operation.

## LOCOMOTIVE CONTROLLER

The locomotive controller is shown in Fig. 2-5. It contains the switches, gauges and operating levers used by the operator during operation of the locomotive. The individual components of the controller are described, together with their functions, in the following paragraphs.

### Air Gauges

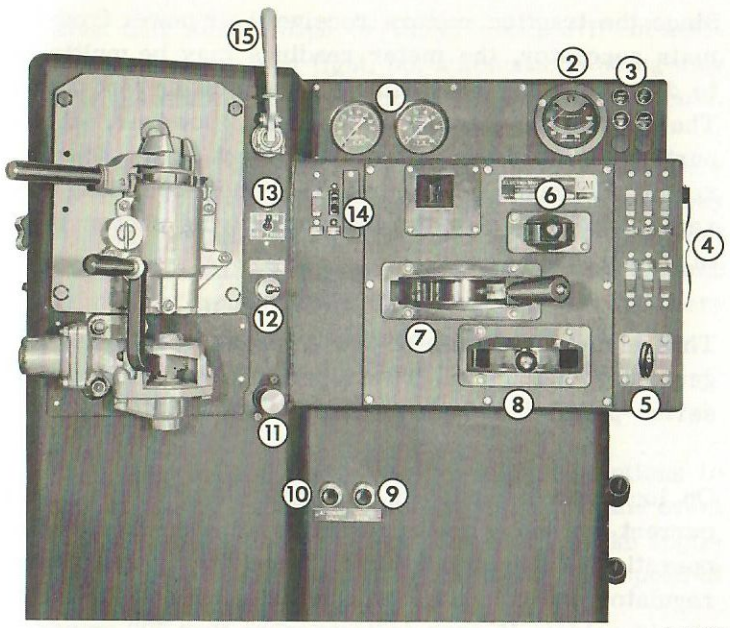
Air gauges to indicate main reservoir air pressure as well as various pressures concerned with the air brakes are prominently located along the top of the controller.

### Load Current Indicating Meter

The locomotive pulling force is indicated by the load current indicating meter located at the upper portion of the controller. This meter is graduated to read amperes of electrical current, with 1500 being the





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1. Air Gauges
2. Load Current Indicating Meter
3. Indicating Lights
4. Operating Switches
5. Headlight Dimming Switch
6. Selector Lever (Optional Extra)
7. Throttle Lever
8. Reverse Lever
9. Ground Reset Pushbutton
10. Attendant Call Pushbutton
11. Bell Pushbutton
12. Sanding Lever
13. Lead Truck Sanding Switch
14. Dynamic Brake Circuit Breaker
15. Air Horn Lever

Fig. 2-5 — Locomotive Controller

maximum reading on the scale. On special order the meter may be color coded to indicate operating time limits at various meter pointer positions.

The meter is connected so as to indicate the current flowing through the No. 2 traction motor. Since the amperage is the same in all motors, each motor will carry the amount shown on the meter.

Since the traction motors receive their power from the main generator, the meter readings may be multiplied to determine the approximate generator current output. The multiplying factor will depend, however, on the particular transition circuit in effect at the time the reading is taken. For example, when operating in a series-parallel circuit, the multiplying factor is 3; in parallel it is 6.

Thus a meter reading of 200 amperes would indicate a generator output of 600 amperes when operating in series-parallel, 1200 in parallel.

On locomotives equipped with dynamic brakes, the load current indicating meter indicates braking effort during operation of dynamic brakes. Since the dynamic brake regulator controls maximum braking current, the meter should seldom if ever indicate more than 700 amperes, which is the rating of the dynamic braking resistor grids.

## Indicating Lights

Four or more indicating lights are installed to provide a visual warning of operating difficulties. The four basic lights are wheel slip, PCS open, brake warning, and sand. The functions of these lights are as follows:

1. Wheel Slip Light

Intermittent flashing of the wheel slip light indicates that the wheel slip control system is doing its job and is correcting the slips. The throttle and locomotive power need not be reduced unless severe lurching threatens to break the train.





Note that minor slips or wheel creep will not activate the wheel slip light, but automatic sanding may take place along with regulation of power to the wheels.

WARNING: A wheel slip light flashing slowly and persistently or burning continuously may indicate a pair of sliding wheels or circuit difficulty. Stop the locomotive and make a careful inspection to ascertain that there are no locked sliding wheels.

2. PCS OPEN Light

The PCS or pneumatic control switch functions to automatically reduce locomotive power in the event that an emergency or safety control air brake application occurs. It does so by reducing the speed of ALL engines to idle.

CAUTION: The engine run switch should be in the OFF position in all trailing units, or (depending on the type and position of locomotives in the consist) it is possible that the PCS switch of the lead unit will not act to reduce engine speeds to idle.

When the switch is tripped the PCS OPEN indicating light on the controller will come on. This light is extinguished and locomotive power restored by resetting the PCS switch. This occurs automatically, provided that:

a. Control of the air brake is recovered.

b. The throttle is returned to IDLE position.

3. Brake Warning

A brake warning light is installed on units equipped with dynamic brakes and functions in conjunction with a brake warning relay. The purpose of the relay and light is to indicate excessive braking current when operating in dynamic braking.

Due to the use of an automatic brake limiting regulator, the warning light should seldom if ever come on and then only momentarily. Correction for excessive current generally occurs automatically and quite rapidly.

In the event that the brake warning light comes on and does not go out quickly, the braking strength should be immediately reduced to prevent possible equipment damage. Excessive braking strength can be reduced by moving the throttle toward idle position.

4. Sand

This light comes on to indicate that the SANDING No. 1 TRUCK switch is closed and that sand is being applied at the No. 1 axle. The light is not affected by the manual, emergency, or wheel slip sanding circuits.

## Operating Switches

A group of switches is located along the front face of the controller, each identified by a name plate indicating switch function. The switches are in the ON position when moved upward.

Before the engine is to be started, the control and fuel pump switch must be placed ON. To obtain power from the locomotive, the generator field switch must be ON.





To obtain control of engine speed, the engine run switch must be ON. These three important switches are grouped at the right side of the controller. They must be placed in the OFF position on controllers of trailing units.

Other switches control sanding, attendant call, and various lights. They are placed on as needed.

## Headlight Dimming Switch

A five position switch is located on the controller to the right of the throttle. In one position it provides for DIM headlights on both ends of the locomotive. In the other positions it provides for a bright or medium headlight at either the front or the rear of the locomotive.

For this switch to function, the two headlight switches on the controller as well as the headlight circuit breaker on the switch and fuse panel must be placed ON.

## Selector Lever

The controller is equipped with a selector lever, Fig. 2-6, in instances where the locomotive unit is equipped with dynamic brakes or when it is necessary to manually control transition on trailing units not equipped for automatic transition. On units so equipped, this lever serves to establish proper circuits for either of these functions.

The position of the lever is indicated in the lower of the two illuminated windows located at the upper left corner of the controller front panel. The lever is spring loaded so that movement all the way in one direction will index the selector cam one notch only in that direction. It must be allowed to return to center position before indexing again in either direction. When the selector lever

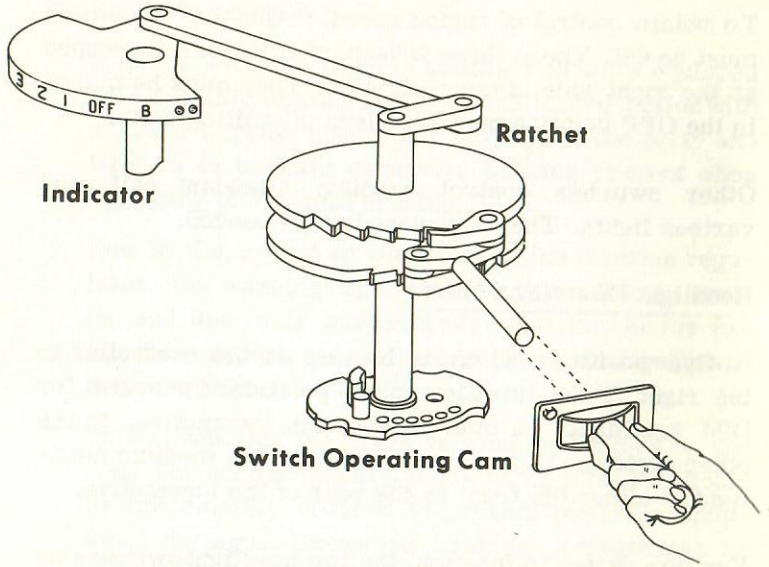


Fig. 2-6 — Selector Lever

is indexed to the B or braking position, the dynamic braking electro-magnetic contactors are energized. In this position the throttle lever moves freely (without notching) to control a braking rheostat and dynamic braking strength.

When the lever is moved to the center or OFF position, all circuits are open. This position is used for locking the controller in unattended or trailing units.

For operation under power, the lever would be indexed to the No. 1 position. Succeeding positions such as Nos. 2, 3 and 4 would be used only when it is necessary to cause transition on any nonautomatic trailing units operating in the locomotive consist.





## Throttle Lever

The throttle lever actuates switches within the controller to establish low voltage electrical circuits to the engine governor for purposes of controlling engine speed. The throttle has ten positions namely, STOP, IDLE and running speeds 1 through 8 as shown in Fig. 2-7. Each of these positions is shown in the illuminated indicator in the upper left hand corner of the controller.

To stop all engines, the throttle lever is pulled out away from the controller and then moved one step beyond IDLE to the STOP position. The IDLE position is as far forward as the throttle lever can be moved without pulling it away from the controller.

Each running notch on the throttle increases the engine speed an average of 84 RPM starting at 315 RPM at IDLE and Run 1 and going to 900 RPM at full throttle.

When operating in dynamic braking (selector lever in "B") the throttle lever serves as a braking handle. It moves freely without notching to control dynamic braking.

## Reverse Lever

The reverse lever, Fig. 2-8, has three positions: forward, neutral and reverse. Direction in which the locomotive moves is controlled by movement of this lever to the forward or reverse position. With the lever in neutral, no power will be developed if the throttle is opened. The reverse lever should be moved ONLY when the locomotive is standing still.

The reverse lever can be removed from the controller only when the lever is in neutral position, the throttle

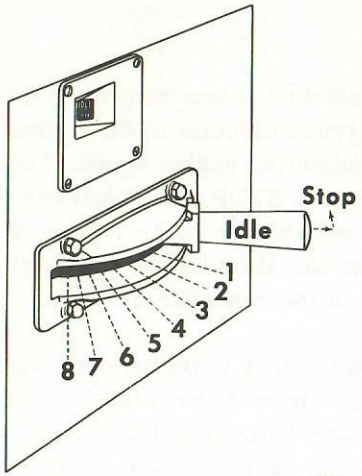


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Fig. 2-7 — Throttle Lever

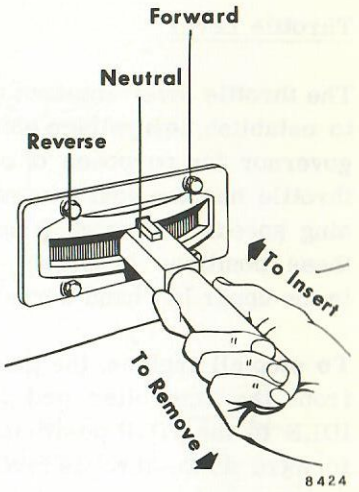


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Fig. 2-8 — Reverse Lever

is in IDLE and the selector lever is in OFF. Removal of the reverse lever locks the operating controls in the controller. The reverse lever should be removed from the controllers in all but the lead unit of a multiple unit locomotive consist.

Bell Ringer

When the bell ringer is operated, compressed air is directed to the locomotive warning bell operator.

Sanding Switches

1. SANDING NO. 1 TRUCK Toggle Switch

The signal from this switch is not trainlined. The switch provides sand to only the number 1 axle of the lead unit of a consist. This method of sanding dresses the rail and is adequate for most conditions.





2. SAND Lever Switch

When the sanding switch lever is operated, electrical energy is directed through interlocks of reverser switchgear to operate either the forward or reverse sanding magnet valves in all units of a consist. The basic switch may be operated in any direction for correct sanding and it is non-latching. A directional sanding switch may be provided as an optional extra, and the switch may be latching if requested by the railroad.

Electrically controlled sanding is the basic system used but since the locomotive may be operated in multiple with older units that are equipped only for pneumatic control of sanding, trainlined pneumatic control of sanding may be provided as an optional extra in addition to electrical control. In such cases, trainlined actuating pipes must be connected between units.

Ground Reset Pushbutton

When a high voltage ground occurs or five main generator diodes in a paralleled group fail, the ground relay operates to drop engine speed and main generator excitation. The alarm bell rings and the H.V. GRD/FAULT light on the engine control panel comes on.

To restore engine speed and locomotive power and silence the alarm, wait 10 seconds then press the ground reset pushbutton on the control stand, Fig. 2-5. It is not necessary to isolate the affected unit before pressing the button. Power will be reapplied smoothly when the protective relay is reset, and the H.V. GRD/FAULT light will go off.

When the alarm rings for the third time after using the GROUND RESET button twice, the affected unit should be isolated.

Indication of ground relay operation is provided for maintenance personnel by a latching relay within the main electrical cabinet. Operating personnel should report ground action in the routine manner established by the railroad and should not tamper with the latching relay within the electrical cabinet.

Attendant Call Pushbutton

The alarm bell rings when this pushbutton is pressed. The button is not latching and does not have to be reset.

## MECHANICAL INTERLOCKS ON THE CONTROLLER

The levers on the controller are interlocked so that:

1. With reverse lever in neutral-

   a. Throttle can be moved to any position.

   b. Selector lever can be moved to any position; OFF, or 1 through 4, except "B."

2. Reverse lever in forward or reverse -

   a. Throttle can be moved to any position.

   b. Selector lever can be moved to any position.

3. Throttle lever in IDLE position -

   a. Reverse lever can be moved to any position.





   b. Selector lever can be moved to any position.

4. Throttle lever in STOP position -

   a. Reverse lever can be moved to any position, but can not be removed from the controller.

   b. Selector lever can be moved to any position.

5. Throttle above IDLE position -

   a. Reverse lever position can not be changed.

   b. Selector lever can not be moved out of "B" into OFF or from 1 to OFF. It may however be moved as desired between 1 and 4.

6. Selector lever in OFF position -

   a. Reverse lever can be moved to any position and removed from controller if throttle lever is in IDLE position.

   b. Throttle can be moved between IDLE and STOP only.

7. Selector lever in "B" position -

   a. Reverse lever can not be moved.

   b. Throttle lever can be moved to any position.

8. Selector lever 1, 2, 3, or 4 -

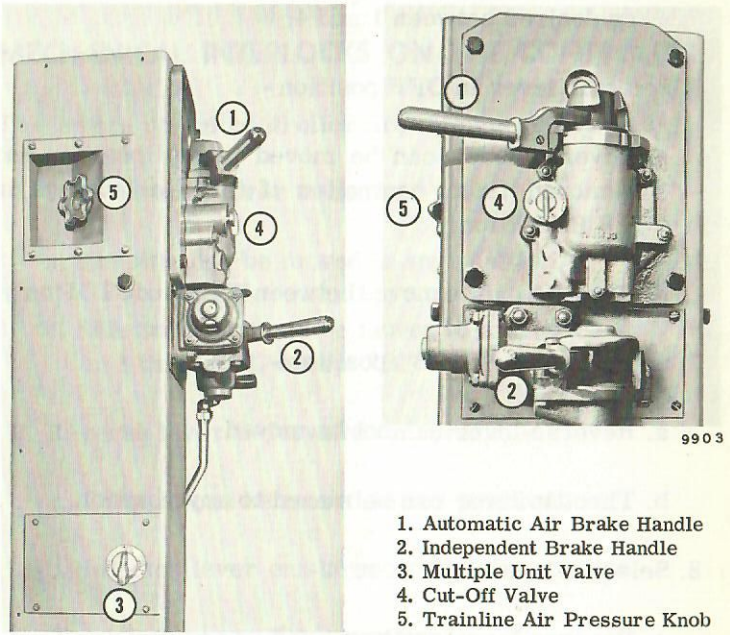
   a. Reverse lever can be moved to any position.

   b. Throttle lever can be moved to any position.

Where positions 2, 3 and 4 are incorporated in the selector for manual transition, the handle may be moved to these positions if the reverse lever is in forward or reverse, and with the throttle in any position. Permissible movement of the throttle and reverse levers with the selector in 2, 3 or 4 is the same as with the selector in 1.

## AIR BRAKE EQUIPMENT, FIG. 2-9

Basic locomotives are equipped with the type 26L air brakes. Since type 26L is standard equipment, only that type of air brake will be discussed in this manual.




1. Automatic Air Brake Handle
2. Independent Brake Handle
3. Multiple Unit Valve
4. Cut-Off Valve
5. Trainline Air Pressure Knob

Fig. 2-9 — 26L Air Brake Equipment





The 26L air brake control equipment is located on a pedestal to the left of the controller. As shown in Fig. 2-9, this equipment consists of an automatic brake, independent brake, multiple unit valve (when MU control is installed), cut-off valve and a trainline air pressure adjustment device. The dead engine fixture, a part of the 26L equipment, is shown in Fig. 2-10. The cock is accessible from outside the locomotive through side doors provided.

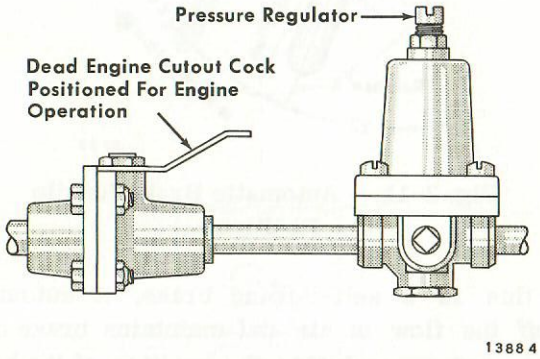



Fig. 2-10 — Dead Engine Cutout Cock

### Automatic Brake Valve

The automatic brake valve handle may be placed in any of six operating positions as shown in Fig. 2-11.

### Independent Air Brake, Fig. 2-12

The independent air brake handle is located directly below the automatic brake handle. It has two positions; namely, RELEASE and FULL APPLICATION. Between these two positions is the application zone.

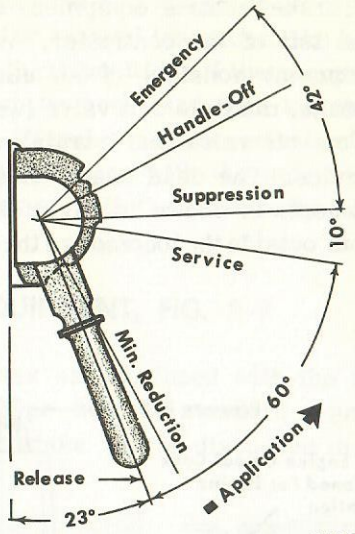



Fig. 2-11 — Automatic Brake Handle Positions

Since this is a self-lapping brake, it automatically laps off the flow of air and maintains brake cylinder pressure corresponding to the position of the handle in the application zone.

Depression of the independent brake valve handle when in the RELEASE position causes release of any automatic brake application existing on the locomotive.

Multiple Unit Valve

The multiple unit (MU-2) valve is located on the left hand side of the air brake pedestal, as shown in Fig. 2-9. Its purpose is to pilot the F1 selector valve which is a device that enables the air brake equipment of one locomotive unit to be controlled by that of another unit.





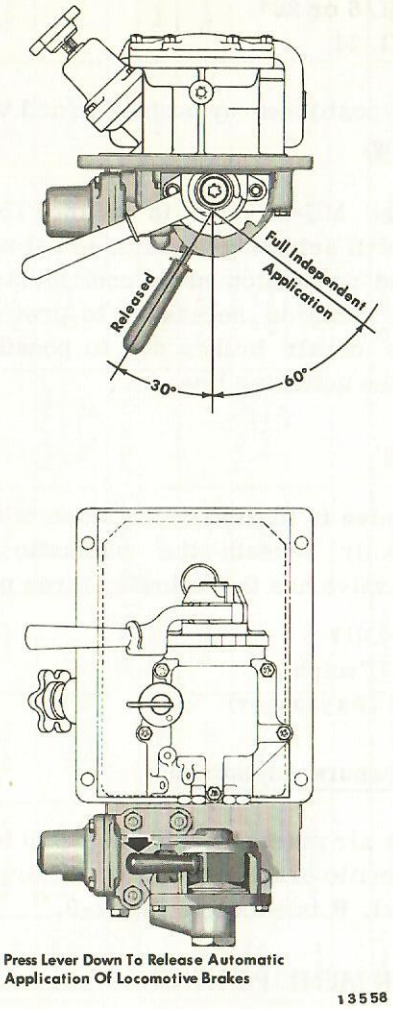



Fig. 2-12 — Independent Brake Handle Positions

The basic MU-2 valve has three positions which are:

1. LEAD or DEAD
2. TRAIL 6 or 26*
3. TRAIL 24

The valve is positioned by pushing in and turning to the desired setting.

*Whenever the MU-2 valve is in the TRAIL 6 or 26 position, and if actuating trainline is not used, then the actuating end connection cutout cock must be opened to atmosphere. This is necessary to prevent the inadvertent loss of air brakes due to possible pressure build-up in the actuating line.

## Cut-Off Valve

The cut-off valve is located on the automatic brake valve housing directly beneath the automatic brake valve handle. This valve has the following three positions:

1. CUT-OUT
2. FRT (Freight)
3. PASS (Passenger)

## Trainline Pressure Adjustment

The trainline air pressure adjusting knob is located behind the automatic brake valve at the upper portion of the brake pedestal. It is shown in Fig. 2-9.

## BRAKE EQUIPMENT POSITIONS

When operating locomotives equipped with 26L air brakes, the brake equipment should be positioned according to the information given in Fig. 2-13.





| Type Of Service | Automatic Brake Valve | Independent Brake Valve | Cutoff Valve | Dead Engine Cutout Cock | 26D Control Valve | 26F Control Valve | MU2 Valve | Overspeed Cutout Cock | Deadman Cutout Cock |
|---|---|---|---|---|---|---|---|---|---|
| **SINGLE LOCOMOTIVE EQUIPMENT** | | | | | | | | | |
| Lead | Release | Release | Passenger Freight | Closed | | Graduated Direct | Lead | Open | Open |
| Double Heading | Suppression | Release | Cutout | Closed | | Graduated Direct | Lead | Open | Open |
| Shipping Dead In Train | Handle Off Position | Release | Cutout | Open | Relief Valve At Control Reservoir 73 ± 2# | Direct | Dead | Closed | Closed |
| **MULTIPLE LOCOMOTIVE EQUIPMENT AND EXTRAS** | | | | | | | | | |
| Lead | Release | Release | Passenger Freight | Closed | | Graduated Direct | Lead | Open | Open |
| Trail | Handle Off Position | Release | Cutout | Closed | | Graduated Direct | *Trail 6 or 26 Trail 24 | Open | Open |
| Shipping Dead In Train | Handle Off Position | Release | Cutout | Open | Relief Valve At Control Reservoir 73 ± 2# | Direct Release | Dead | Closed | Closed |
| Double Heading | Suppression | Release | Cutout | Closed | | Graduated Direct | Lead | Open | Open |
| Dual Control: | | | | | | | | | |
| Operative Station | Release | Release | Passenger Freight | Closed | | Graduated Direct | Lead | Open | Open |
| Non-Operative Station | Handle Off Position | Release | Cutout | | | | | | |

*Whenever the MU2A valve is in "Trial 6 or 26" position and if the actuating train line is not used, then the actuating end connection cutout cock must be open to atmosphere; so as to prevent the inadvertant loss of air brakes due to possible pressure buildup in the actuating line.

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Fig. 2-13 — Brake Equipment Positions

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# SECTION 3

# OPERATION

## INTRODUCTION

This section of the manual covers recommended procedures for operation of the locomotive. The procedures are briefly outlined and do not contain detailed explanations of equipment location or function.

The information in this section is arranged in sequence, commencing with inspections in preparation for service, and with instructions for starting the engine, handling a light locomotive, coupling to train, and routine operating phases. The various operating situations and special features such as dynamic braking are also covered.

## PREPARATION FOR SERVICE

### GROUND INSPECTION

Check locomotive exterior and running gear for:

1. Leakage of fuel oil, lube oil, water or air.
2. Loose or dragging parts.
3. Proper hose connections between units in multiple.
4. Proper positioning of all angle cocks and shut-off valves.
5. Air cut-in to truck brake cylinders.
6. Satisfactory condition of brake shoes.
7. Adequate supply of fuel.
8. Proper installation of control jumper cables between units.

## LEAD UNIT CAB INSPECTION

On the lead or control unit, the control locations described in Section 2 should be checked and the equipment positioned for operation as follows:

### Fuse And Switch Panel

1. Main battery switch closed.
2. Ground relay knife switch closed.
3. All fuses installed and in good condition. Particular attention should be paid to the generator field fuses, since one of the two fuses may be open without loss of locomotive power. If the generator field fuses are removed for any reason, they should always be tested before being replaced.

### Circuit Breaker Panel

1. Control circuit breaker ON.
2. Local control circuit breaker ON.
3. Fuel pump and turbo lube pump circuit breakers ON.
4. Lights circuit breakers and miscellaneous circuit breakers ON as needed.

### Engine Control Panel

1. Isolation switch in START position.
2. Headlight control switch in proper position for lead unit operation.
3. Miscellaneous switches and circuit breakers ON as required.

CAUTION: The electrical cabinet is pressurized with filtered air. Cabinet doors must be securely closed during locomotive operation.







### Field Loop Panel (When Provided)

1. Unit selector switch, Fig. 2-4, in position corresponding with total number of units in locomotive consist.
2. Operation selector switch in FIELD LOOP or POTENTIAL position depending upon makeup of the locomotive consist.
   a. If all units in a mixed consist are equipped with potential line control of dynamic brakes, do not connect the field loop cables. If the units are equipped with an operation selector switch, place all such switches in the POTENTIAL position.
   b. If one or more units in a mixed consist are equipped only for field loop control of dynamic braking, connect all units in the field loop, and place the operation selector switches on all units in the FIELD LOOP position.

### Locomotive Controller

The controller switches and operating levers should be positioned as follows:

1. Place control and fuel pump switch in ON (up) position.
2. Make sure throttle remains in IDLE position and reverse lever is removed from controller.

### Air Brakes - Type 26L

1. Insert automatic brake valve handle (if removed) and place in SUPPRESSION position. This will nullify the application of any safety control equipment used.

2. Insert independent brake valve handle (if removed) and move to FULL APPLICATION position.

3. Position cutoff valve to either FRGT or PASS depending on make-up of train.

4. Place MU valve in LEAD position.

ENGINEROOM INSPECTION

The engine can be readily inspected by opening the access doors along the sides of the long hood end of the locomotive.

1. Check air compressor for proper lubricating oil supply.

2. Observe for proper water level on tank sight glass.

NOTE: Low water detector may trip at engine start. It must then be reset immediately.

3. Check all valves for proper positioning.

4. Observe for leakage of fuel oil, lubricating oil, water or air.

ENGINE INSPECTION

The engine should be inspected before as well as after starting. After inspection and engine start, all engine room doors should be closed and latched securely.

1. Check to see that engine overspeed lever is set, Fig. 3-1.

2. Observe that governor low oil pressure trip button, Fig. 3-1, is set and that there is oil visible in the governor sight glass.





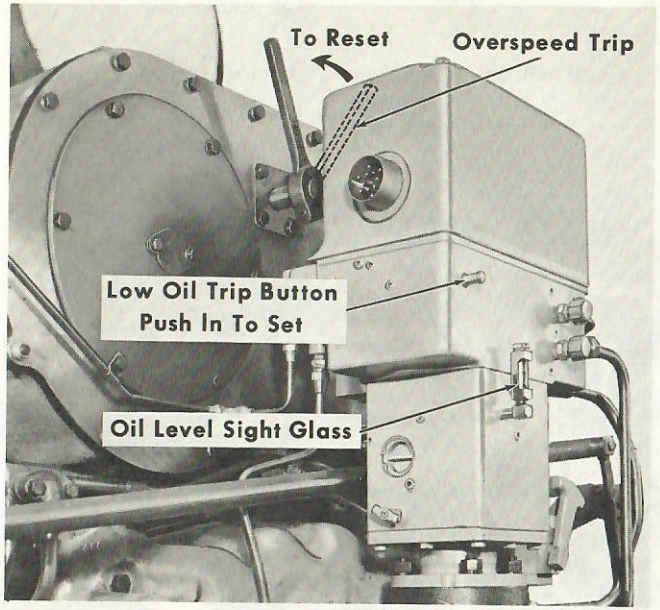


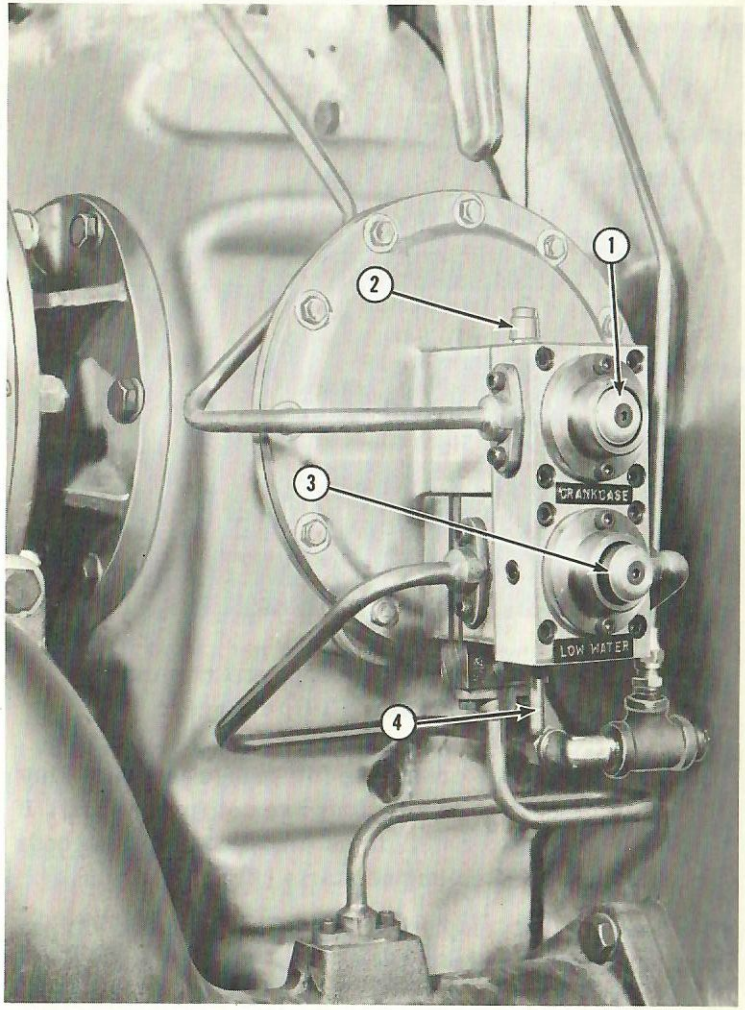

Fig. 3-1 — Engine Overspeed Trip And Low Oil Pressure Trip Plunger

3. Observe that the crankcase (oil pan) pressure and low water detector reset buttons are set (pressed in). If the buttons protrude, press and hold for 5 seconds immediately after engine starts (Fig. 3-2).

4. Observe that engine top deck, air box and oil pan inspection covers are in place and are securely closed.

## STARTING THE DIESEL ENGINE

After the preceding inspections have been completed, the diesel engine may be started. Starting controls are located at the accessory end of the engine in the area of the equipment rack. See Fig. 2-1.

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1. Crankcase Pressure Reset
2. Vent And Test Opening
3. Low Water Reset
4. Test Cock

Fig. 3-2 — Low Water And Crankcase (Oil Pan) Pressure Detector





Perform the following:

1. Place the fuel prime / engine start switch in the FUEL PRIME position and hold it there for 10 to 15 seconds to prime the fuel system.

2. Grasp the layshaft lever, then perform the following:

   Position the layshaft lever about one-third rack (about 1.6 on the scale) before cranking is started. Then move the fuel prime/engine start switch to the ENGINE START position. Do not crank the engine for more than 20 seconds at an attempt, and always allow a full 2 minute cool-down period between each cranking attempt. As the engine starts, release the layshaft lever as soon as governor control of injector linkage is felt at the lever.

CAUTION: Do not crank the engine for short repeated intervals to turn an engine over. Such cranking can overheat and destroy starting components.

If the engine does not start after 20 seconds of free cranking, release the starting switch. Allow 2 minutes between cranking attempts. This will allow the cranking motors to cool.

Note that the compressor control strainer drain valve located at the base of the AC cabinet will blow during engine start until air pressure at the valve builds to 20 psi.

3. Check that engine oil pressure, engine oil level, and governor oil level are satisfactory. Immediately after engine starts check reset buttons on detector and hold in for 5 seconds if needed.

4. Check that the engine cooling water level does not fall below the "LOW" mark on the "Engine Running" portion of the water level gauge plate. If the water level is slightly low, the engine may continue to run at idle speed, but may shut down when the throttle is advanced.

## TRAILING UNIT CAB INSPECTION

Switches, circuit breakers and control equipment located in the cab of a trailing unit should be checked for proper positioning as follows:

### Fuse And Switch Panel

1. All knife switches closed.
2. All fuses installed and in good condition.

### Circuit Breaker Panel

1. Local control circuit breaker ON.
2. Control circuit breaker ON.
3. Fuel pump circuit breaker ON.
4. Turbo lube pump circuit breaker ON.

### Engine Control Panel

1. Isolation switch in START position, and headlight control switch in position to correspond with unit position in consist.





2. Other switches may be placed ON as needed or left off, as they do not affect locomotive operation.

### Field Loop Panel (When Provided)

1. Unit selector switch, Fig. 2-4, has no function in trailing units, it may be placed in any position.
2. Operation selector switch placed in the same position as in the lead unit of the locomotive consist.

### Locomotive Controller

The controller switches and operating levers should be positioned as follows:

1. Control and fuel pump switch, generator field switch, and engine run switch must be OFF.
2. Throttle in IDLE.
3. Selector lever in OFF.
4. Reverse lever placed in neutral and then removed from the controller to lock the other levers.

### Air Brakes - Type 26L

1. Place automatic brake valve handle in HANDLE OFF position. Remove handle (if so equipped).
2. Place independent brake valve handle in FULL RELEASE position. Remove handle (if so equipped).
3. Place MU valve in desired position for trailing unit operation.
4. Place cutoff valve in CUTOUT position.

## STARTING TRAILING UNIT DIESEL ENGINES

Engines in trailing units are started in the same manner as the engine in the lead unit.

## PLACING UNITS ON THE LINE

After the diesel engines are started and inspected, units may be placed on the line as desired by placing the isolation switch on the engine control panel in the cab in the RUN position. If the consist is at a standstill, be certain that the throttle lever in all units is in the idle position before placing any unit on the line.

## PRECAUTIONS BEFORE MOVING LOCOMOTIVE

The following points should be carefully checked before attempting to move the locomotive under its own power:

1. MAKE SURE THAT MAIN RESERVOIR AIR PRESSURE IS NORMAL (approximately 130-140 pounds).

   This is very important, since the locomotive is equipped with electro-magnetic switchgear which will function in response to control and permit operation without air pressure for brakes.

2. Check for proper application and release of air brakes.

3. Release hand brake and remove any blocking under the wheels.

## HANDLING LIGHT LOCOMOTIVE

With the engine started and placed "on-the-line" and the preceding inspections and precautions completed, the locomotive is handled as follows:





1. Place the engine run switch and generator field switch in ON (up) position.

2. Place headlight and other lights ON as needed.

3. Insert reverse lever and move it to desired direction of travel, either forward or reverse.

4. Place selector lever in No. 1 position (if so equipped).

5. Depress safety control foot pedal (if so equipped).

6. Release air brakes.

7. Open throttle to Run 1, 2 or 3 as needed to move locomotive at desired speed.

NOTE: Locomotive response to throttle movement is almost immediate. There is little delay in power buildup.

Engine should not be operated above throttle position No. 3 until water temperature is greater than 130° F.

8. Throttle should be in IDLE before coming to a dead stop.

9. Reverse lever should be moved to change direction of travel only when locomotive is completely stopped.

## DRAINING OF AIR RESERVOIRS AND STRAINERS

The air reservoirs and air strainers or filters should be drained at least once each day whether or not equipment is provided with automatic drain valves. Draining should be done at the time of crew change until a definite schedule is established by the railroad.

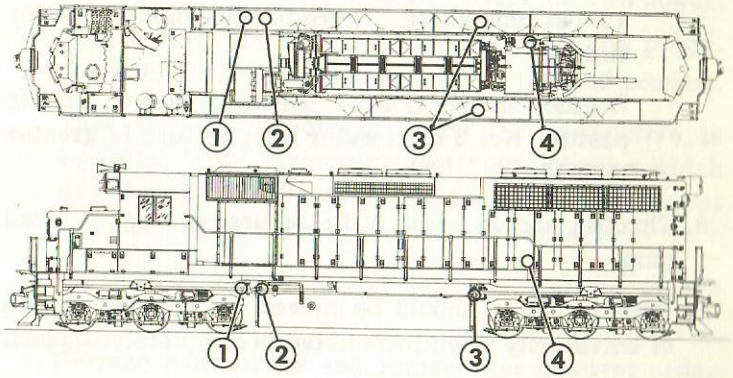
Drain valves should be operated at the following locations:

1. Momentarily operate the manual override lever on auxiliary main reservoir centrifugal filter, 2, Fig. 3-3 and Fig. 3-4.

2. Momentarily operate the manual override lever on the main reservoir centrifugal filter, 1, Fig. 3-3 and Fig. 3-4.

3. Momentarily open the main reservoir drain valves, 3, Fig. 3-3.

4. Press up on the pushbutton at the base of the compressor control strainer drain, 4, Fig. 3-3 and Fig. 3-5.

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1. Main Reservoir Centrifugal Filter And Drain
2. Auxiliary Main Reservoir Centrifugal Filter And Drain
3. Main Reservoir Drain Valve Location
4. Compressor Control Strainer Drain Valve Location

Fig. 3-3 — Compressed Air System Drain Valve Locations





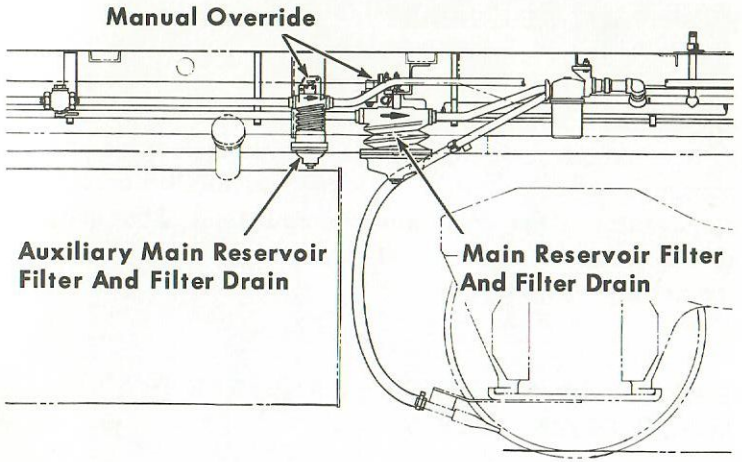


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Fig. 3-4 — Main And Auxiliary Main Reservoir Centrifugal Filters And Filter Drains

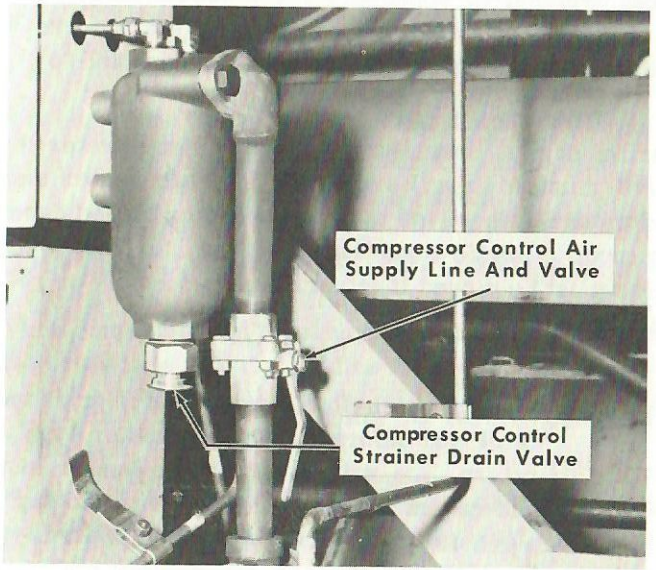


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Fig. 3-5 — Compressor Control Strainer Drain Valve

## ENGINE AIR BOX DRAIN

A metal casting mounted on the front end plate of the engine connects drain pipes from each side of the airbox to a common drain pipe. Pressures in opposition at the casting restrict airflow to a permissible amount, yet allow elimination of airbox contaminants. The system is completely automatic and requires no attention by the locomotive operator.

## ENGINE, AIR COMPRESSOR, AND CAB HEATER WATER DRAIN VALVES

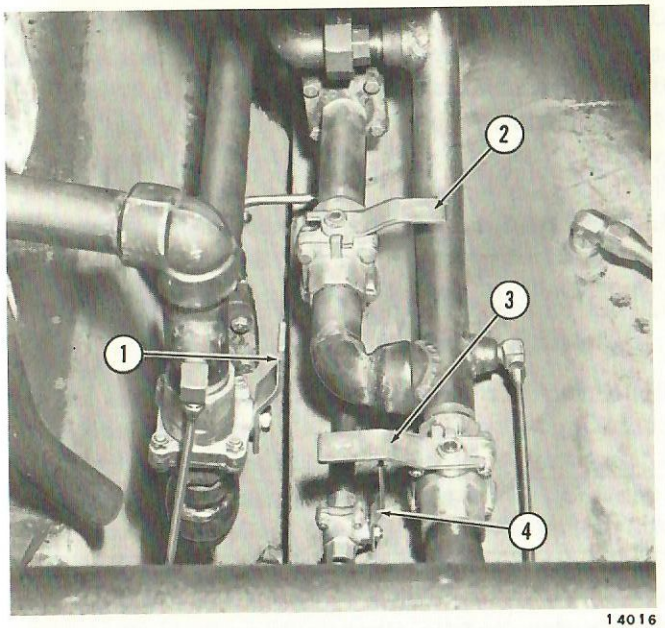
Two engine water drain valves are located at the engine sump between the engine and accessory rack. Cab heater supply and return line valves are located in the same area. When it is necessary for a locomotive operator to shut down an engine and drain it, all four valves, Fig. 3-6, should be opened (valve handles parallel to pipe).

During engine operation, the main engine water drain valve must always be closed. The cab heater supply and return line valves may be opened or closed depending upon climatic conditions, but the cab heater drain valve must be closed if either the heater supply or return line valve is open.

CAUTION: Always check that the cab heater drain valve is closed before opening the heater supply or return line valves. When the heater supply and return line valves are closed and there is a possibility of freezing weather, water should be drained from the cab heaters and piping.








1. Cab Heater Return Line Valve
2. Cab Heater Supply Line Valve
3. Cooling System Drain Valve
4. Emergency Cab Heater Drain Valve

Fig. 3-6 — Engine And Cab Heater Drain Valve Location

## COUPLING LOCOMOTIVE UNITS TOGETHER

When coupling units together for multiple unit operation, the procedure below should be followed:

1. Couple and stretch units to insure couplers are locked.
2. Install control cable between units; also dynamic braking cables, if so equipped, and if operation with field loop control of dynamic brakes is desired.

NOTE: If the consist is made up with older units that are equipped for only pneumatic control of sanding, connect actuating pipes between all units in the consist.

3. Attach platform safety chains between units.

4. Perform ground, engineroom and engine inspections as outlined in preceding articles.

5. Position cab controls for trailing unit operation as outlined in preceding articles.

6. Connect air brake hoses between units as shown in Fig. 3-7.

| Unit equipped with 26L brake equipment to operate in multiple (lead or trail) with 24RL or 6BL units. | | | | |
|---|---|---|---|---|
| 6BL | | 26L | | 24RL |
| Brake pipe | to | Brake pipe | to | Brake pipe |
| MR equalizing pipe | to | MR equalizing pipe | to | MR equalizing pipe |
| - | | Actuating pipe | to | Actuating pipe |
| BC equalizing pipe | to | BC equalizing pipe | to | Indep. applic. & rel. pipe |
| Sanding pipe | to | Sanding pipe | to | Sanding pipe |

12871

Fig. 3-7 — Brake Pipe Connections Between Units

7. Open required air hose cutout cocks on both units.

NOTE: Units with 26L brake equipment must have the actuating pipe end hose cutout cock CLOSED at the rear of the locomotive when they are leading units with 6SL or 6BL brake equipment. If two or





more units of 26L brake equipment are connected together and leading the consist, the end hoses must be coupled together between units and the cutout cocks on the actuating pipe line OPENED on each unit. Units with 26L brake equipment must have the actuating pipe cutout cock OPEN at both ends when attached to, but trailing units with 6SL or 6BL brake equipment. (This is required to eliminate an undesired brake action occurring on the locomotive.)

A setup of the brakes must then be made on the consist to determine if brakes apply on each unit. Brakes then must be released to determine if all brakes release. The same procedure must be followed to check the independent brake application. Also, release an automatic service application by depressing the independent brake valve handle downward. Inspect all brakes in the consist to determine if they are released.

## COUPLING LOCOMOTIVE UNITS TOGETHER FOR DYNAMIC BRAKING IN MIXED CONSISTS

The SD45 locomotive, when equipped with basic dynamic brakes, makes use of electrical potential from the brake control rheostat to control braking strength by controlling excitation of the main generator field. This electrical potential is impressed upon a trainlined wire to control dynamic braking strength of all units in a consist equipped with potential line brake control.

If the SD45 is to be used with older locomotives that are not equipped with potential line brake control, equipment for field loop control of dynamic brakes may be provided in one of two forms.

1. To lead only with field loop control of dynamic brakes.

2. To lead or trail with field loop control of dynamic brakes.

If the unit is equipped to lead or trail in field loop, it is provided with an operation selector switch located in the short hood. Units equipped to lead only in field loop are not provided with an operation selector switch. Such units must be in the lead if field loop control of dynamic braking is to be used.

Any instructions regarding mixed consist dynamic braking must consider the equipment provided on the units involved, the position of the various units in the consist, and individual railroad policy and rules. However, the following general suggestions may be helpful in cases where doubt regarding braking arrangements exists. These suggestions should not be followed if they conflict with railroad rules.

1. If all units in a mixed consist are equipped with potential line control of dynamic brakes, do not connect the field loop cables. If the units are equipped with an operation selector switch, place all such switches in the POTENTIAL position.

2. If one or more units in a mixed consist are equipped only for field loop control of dynamic braking, connect all units in the field loop, and place the operation selector switches on all units in the FIELD LOOP position. (GP30 and later models not equipped with an operation selector switch can not trail in field loop.)





## COUPLING LOCOMOTIVE TO TRAIN

Locomotive should be coupled to train using the same care taken when coupling units together. After coupling, make the following checks:

1. Test to see that couplers are locked by stretching connection.

2. Connect air brake hoses.

3. Slowly open air valves on locomotive and train to cut in brakes.

4. Pump up air if necessary, using the following procedure.

## PUMPING UP AIR

After cutting in air brakes on train, note the reaction of the main reservoir air gauge. If pressure falls below trainline pressure, pump up air as follows:

1. Place generator field switch in OFF (down) position.

2. Move reverse lever to neutral position.

3. Open throttle as needed to speed up engine and thus increase air compressor output.

NOTE: Throttle may be advanced to RUN 4 or 5 if necessary. Engine should not however be run unloaded (as in pumping up air) at speeds beyond throttle No. 5 position.

## BRAKE PIPE LEAKAGE TEST

Prior to operating the 26L brake equipment, a leakage test must be performed. This is accomplished in the following manner.

1. The cutoff valve is positioned in either FRGT or PASS, depending on the equipment make up of the train.
2. Move the automatic brake valve handle gradually into service position until the equalizing reservoir gauge indicates that a 15 psi reduction has been made.
3. Without any further movement of the automatic brake valve handle, observe the brake pipe gauge until this pressure has dropped 15 psi and exhaust has stopped blowing.
4. At this moment turn the cutoff valve to CUT OFF position. This cuts out the maintaining function of the brake valve.
5. From the instant the cutoff valve is turned to CUT OFF position, the brake pipe gauge should be observed and any possible drop in brake pipe pressure should be timed for one minute. Brake pipe leakage must not exceed the rate established by railroad rules.
6. After checking trainline leakage for one minute and the results are observed to be within required limits, return the cutoff indicator to the required position (FRGT or PASS) and proceed to reduce the equalizing gauge pressure until the pressure is the same as brake pipe gauge pressure. This is accomplished by moving the automatic brake valve handle gradually to the right until a full service application has been obtained.





7. After pipe leakage test has been completed, return the automatic brake valve handle to RELEASE position.

## STARTING A TRAIN

The method to be used in starting a train depends upon many factors such as, the type of locomotive being used; the type, weight and length of the train and amount of slack in the train; as well as the weather, grade and track conditions. Since all of these factors are variable, specific train starting instructions cannot be provided and it will therefore be up to the operator to use good judgment in properly applying the power to suit requirements. There are, however, certain general considerations that should be observed. They are discussed in the following paragraphs.

A basic characteristic of the diesel locomotive is its HIGH STARTING TRACTIVE EFFORT, which is DIRECTLY RELATED TO THROTTLE POSITION. The design of the locomotive power control system is such that tractive effort is low in low throttle position and high in high throttle position, and this effort is available immediately as the throttle is positioned. These characteristics make the use of independent locomotive brakes or the manipulation of the throttle between run 1 and idle generally unnecessary during starting.

The available tractive effort does however make it imperative that the air brakes be completely released before any attempt is made to start a train. On an average 100 car freight train having uniformly distributed leakage, it may take 10 minutes or more to completely release the brakes after a reduction has been made. It is therefore important that sufficient time be allowed

after stopping, or otherwise applying brakes, to allow them to be fully released before attempting to start the train.

The locomotive possesses sufficiently high tractive effort to enable it to start most trains without taking slack. The practice of taking slack indiscriminately should thus be avoided. There will, however, be instances in which it is advisable (and sometimes necessary) to take slack in starting a train. Care should be taken in such cases to prevent excessive locomotive acceleration which will cause undue shock to draft gear and couplers, and lading.

Proper throttle handling is important when starting trains, since it has a direct bearing on the power being developed. As the throttle is advanced, a power increase occurs almost immediately, and power applied is at a value dependent upon throttle position. It is therefore advisable to advance the throttle one notch at a time when starting a train. A train should be started in as low a throttle position as possible, thus keeping the speed of the locomotive at a minimum until all slack has been removed and the train completely stretched. Sometimes it is advisable to reduce the throttle a notch or two at the moment the locomotive begins to move in order to prevent stretching slack too quickly or to avoid slipping.

When ready to start, the following general procedure is recommended:

1. Place the selector lever (if used) in the No. 1 position.

2. Move reverse lever to the desired direction, either forward or reverse.





3. Place engine run and generator field switches in the ON (up) position.

4. Release both automatic and independent air brakes.

5. Open the throttle one notch every few seconds as follows:

   a. To run 1 — The engine will quickly load, but the loading will stop at a specific low value. This may be noted on the load indicating meter. At an easy starting place the locomotive may start the train.

NOTE: The design of the locomotive power control system makes it generally unnecessary to apply locomotive independent brakes or to manipulate the throttle between run 1 and idle during starting.

   b. To run 2, 3 or higher (experience and the demands of the schedule will determine this) until the locomotive moves.

6. Reduce throttle one or more notches if acceleration is too rapid.

7. After the train is stretched, advance throttle as desired.

NOTE: When operating at full power to climb a hill, the wheel slip light may indicate slipping. In such case do not reduce throttle unless severe lurching occurs and there is danger of pulling the train apart.

## ACCELERATING A TRAIN

After the train has been started, the throttle can be advanced as rapidly as desired to accelerate the train. The speed with which the throttle is advanced depends upon demands of the schedule and the type of locomotive and train involved. In general however, advancing the throttle one notch at a time is desired to prevent slipping.

The load indicating meter provides the best guide for throttle handling when accelerating a train. By observing this meter it will be noted that the pointer moves toward the right (increased amperage) as the throttle is advanced. As soon as the increased power is absorbed, the meter pointer begins moving toward the left. At that time, the throttle may again be advanced. Thus for maximum acceleration without slipping, the throttle should be advanced one notch each time the meter pointer begins moving toward the left until full power is reached in throttle position 8.

Additional train acceleration is provided by motor field shunting and by changing motor connections with the main generator from three groups of two motors in series to six motors in parallel. This takes place automatically during throttle changes or after reaching full throttle. This change of electrical circuits takes place automatically without any attention or action required on the part of the operator.

NOTE: In the event that trailing locomotive units are not equipped with automatic transition, manual shifting of the lead unit selector lever will be necessary to cause transition on such units. The shift points (1 through 4) are based on speed. Such information is provided by the railroad or may be obtained from Electro-Motive Division of General Motors on request.





## DRAG DUTY PERFORMANCE CONTROL

The SD45 locomotive is equipped with a performance control circuit that regulates locomotive horsepower within adhesion considerations at low speeds. The control is calibrated in accordance with railroad requirements to give performance characteristics matching the tractive effort capabilities of the SD45 with less powerful locomotives.

This control enables the SD45 in drag service to operate at continuous speeds compatible with earlier and less powerful models. At lower speeds power is maintained, but it is necessary to observe short time ratings.

## SLOWING DOWN BECAUSE OF A GRADE

When starting to climb a hill, the locomotive and train will slow down and the increased load will be indicated by load indicating meter pointer movement toward the right. Backward transition will take place automatically. (See note under Accelerating A Train.)

## AIR BRAKING WITH POWER

The method of handling the air brake equipment is left to the discretion of the individual railroad. However, when braking with power, it must be remembered that for any given throttle position, the draw bar pull rapidly increases as the train speed decreases. This pull might become great enough to part the train unless the throttle is reduced as the train speed decreases. Since the pull of the locomotive is indicated by the amperage on the load meter, the operator can maintain a constant pull on the train during a slow down, by keeping a steady amperage on the load meter. This is accomplished by reducing the throttle a notch whenever the amperage starts

to increase. It is recommended that the independent brakes be kept fully released during power braking. The throttle MUST be in Idle before the locomotive comes to a stop.

## OPERATING OVER RAIL CROSSING

When operating the locomotive at speeds exceeding 25 MPH, reduce the throttle to a RUN 4 position at least eight seconds before the locomotive reaches a rail crossing. If the locomotive is operating in RUN 4 position or lower, or running less than 25 MPH, allow the same interval and place the throttle in the next lower position. Advance the throttle after all units of the consist have passed over the crossing. This procedure is necessary to ensure decay of motor and generator voltage to a safe level before the mechanical shock that occurs at rail crossings is transmitted to the motor brushes.

## RUNNING THROUGH WATER

Under ABSOLUTELY NO CIRCUMSTANCES should the locomotive be operated through water deep enough to touch the bottom of the traction motors. Water any deeper than 3" above the rail is likely to cause traction motor damage.

When passing through any water on the rails, exercise every precaution under such circumstances and always go very slowly, never exceeding 2 to 3 MPH.

## WHEEL SLIP LIGHT INDICATIONS

Automatic sanding, together with reduction of locomotive power functions to correct wheel slip. After adhesion is regained, a timed application of sand continues while





power is smoothly restored. The system functions entirely automatically, and no action is required by the locomotive operator.

NOTE: Throttle reduction is recommended only when slip conditions are such that repeated wheel slip causes severe lurching that may pull a train apart.

Depending upon the seriousness of slipping, the wheel slip light may or may not flash on and off as the wheel slip control system functions to correct the slips. Normal intermittent flashing of the light indicates that the wheel slip system is doing its job and is correcting the slips, but correction of wheel slips without the light flashing on and off is the normal condition. No action is required by the operator.

If the wheel slip light blinks on and off slowly and persistently or burns continuously during locomotive operation, a pair of wheels may be sliding or circuit difficulty may exist. Due to the seriousness of sliding wheels, under such indications the locomotive should be IMMEDIATELY STOPPED and an investigation made to determine the cause. The wheels may be sliding due to a locked brake, damaged traction motor bearings, or broken pinion or gear teeth.

Repeated ground relay tripping, accompanied by unusual noises such as thumping or squealing, may also indicate serious traction motor trouble that should be investigated at once.

Do not allow any unit that must be isolated due to repeated wheel slip or ground relay action to remain in a locomotive consist UNLESS IT HAS BEEN ABSOLUTELY DETERMINED THAT ALL OF ITS WHEELS ROTATE FREELY.

## LOCOMOTIVE SPEED LIMIT

The maximum speed at which the locomotive can be safely operated is determined by the gear ratio. This ratio is expressed as a double number such as 62:15. The 62 indicates the number of teeth on the axle gear while the 15 represents the number of teeth on the traction motor pinion gear.

Since the two gears are meshed together, it can be seen that for this particular ratio the motor armature turns approximately four times for a single revolution of the driving wheels. The locomotive speed limit is therefore determined by the maximum permissible rotation speed of the motor armature. Exceeding this maximum could result in serious damage to the traction motors.

Various gear ratios are available to suit specific locomotive operating requirements. For each gear ratio, there is a maximum operating speed. This information is given in the "General Data" section at the beginning of this manual.

Although not basically applied, overspeed protective equipment is available for installation on locomotives. The equipment consists of an electro-pneumatic arrangement with many possible variations to suit specific requirements. In general, however, an electrical switch in the speed recorder is used to detect the over-speed. This switch in turn initiates certain air brake functions which reduce the train speed.

## MIXED GEAR RATIO OPERATION

If the units of the consist are of different gear ratios, the locomotive should not be operated at speeds in excess of that recommended for the unit having the lowest





maximum permissible speed. Similarly, operation should never be slower than the minimum continuous speed (or maximum motor amperage) for units having established short time ratings.

To obtain a maximum tonnage rating for any single application, Electro-Motive will, upon request, analyze the actual operation and make specific tonnage rating recommendations.

## DYNAMIC BRAKING

Dynamic braking, on locomotives so equipped, can prove extremely valuable in retarding train speed in many phases of locomotive operation. It is particularly valuable while descending grades, thus reducing the necessity for using air brakes.

Depending on locomotive gear ratio, the maximum braking strength is obtained between 18 and 25 MPH. At train speeds higher than the optimum, braking effectiveness gradually declines as speed increases. For this reason, it is important that dynamic braking is started BEFORE train speed becomes excessive. While in dynamic braking, the speed of the train should not be allowed to "creep" up by careless handling of the brake.

If the locomotive is equipped with the basic dynamic brake, braking strength rapidly declines as speed falls below the optimum (nominally 23 MPH). However, on special order the extended range dynamic brake may be provided. The extended range system maintains near maximum braking strength down to train speed of about 6 MPH. At lower train speeds dynamic braking strength declines rapidly.

To operate dynamic brakes, proceed as follows:

1. On units equipped with a field loop circuit for control of dynamic brakes, observe that the unit selector switch position in the lead unit corresponds to the number of units in the locomotive consist.

2. The reverse lever must be positioned in the direction of the locomotive movement.

3. Throttle must be reduced to idle.

4. Move selector from No. 1 to OFF position. Pause 10 seconds before proceeding.

5. Move the selector lever to the "B" or braking position. This establishes the dynamic braking circuits. It will also be noted that a slight amount of braking effort occurs, as evidenced by the load current indicating meter.

6. After the slack is bunched, the throttle is used to control dynamic braking strength. As it is advanced about 13° away from IDLE it will be noted that the engine speed automatically increases.

7. Braking effort may be increased by slowly advancing the throttle to the full 8th position if desired. Maximum braking effort is automatically limited to 700 amperes by a dynamic brake current limiting regulator.

8. With automatic regulation of maximum braking strength, the brake warning light on the controller should seldom give indication of excessive braking current. If the brake warning light does flash on however, movement of the throttle handle should be stopped until the light goes out.





9. If the light fails to go out after several seconds, move the throttle handle back towards IDLE slowly until the light does go out. After the light goes out, throttle may again be advanced to increase braking effort.

NOTE: The brake warning light circuit is "trainlined" so that a warning will be given in the lead unit if any unit in the consist is generating excessive current in dynamic braking. Thus regardless of the load indicating meter reading (which may be less than brake rating), whenever the warning light comes on, it should not be allowed to remain on for any longer than two or three seconds before steps are taken to reduce braking strength.

10. When necessary, the automatic brake may be used in conjunction with the dynamic brake. However, the independent brake must be KEPT FULLY RELEASED whenever the dynamic brake is in use, or the wheels may slide. As the speed decreases below 10 MPH the basic dynamic brake becomes less effective. When the speed further decreases, it is permissible to completely release the dynamic brake by placing the selector lever in the OFF or No. 1 position, applying the independent brake simultaneously to prevent the slack from running out.

The locomotive can be operated in dynamic braking when coupled to older units that are not equipped with brake current limiting regulators. If all the units are of the same gear ratio, the unit having the lowest maximum brake current rating should be placed as the lead unit in the consist. The operator can then operate and control the braking effort up to the limit of the unit having the lowest brake current rating, without overloading the dynamic brake system of a trailing unit. The locomotive

consist MUST always be operated so as not to exceed the braking current of the unit having the lowest maximum brake current rating.

Units equipped with dynamic brake current limiting regulators can be operated in multiple with SD45 locomotives in dynamic braking regardless of the gear ratio or difference in the maximum brake current ratings.

Units not equipped with dynamic brake current limiting regulators and of different gear ratios will require special operating instructions when used in multiple with a SD45 locomotive in dynamic braking.

## DYNAMIC BRAKE WHEEL SLIDE CONTROL

Electrical relays in a bridge circuit with traction motors are used to correct the tendency of one pair of wheels to rotate slower due to an unusual rail condition while in dynamic braking.

When a pair of wheels is detected tending to rotate at a slower speed, the retarding effort of the traction motors in the unit affected is reduced (traction alternator field excitation is reduced in the unit affected) and sand is automatically applied to the rails. When the retarding effort of the traction motors in the unit is reduced, the tendency of the wheel set to rotate at a slower speed is overcome. After the wheel set resumes normal rotation, the retarding effort of the traction motors returns (increases) to its former value. Automatic sanding continues for approximately 8 seconds after the wheel slide tendency is corrected.

## DOUBLE HEADING

Prior to double heading behind another locomotive, make a full service brake pipe reduction with the automatic





brake valve, and place the cutoff valve in CUTOUT position. Return the automatic brake valve handle to the release position and place the independent brake valve in release position. On 26L equipment place the MU valve in LEAD position.

The operation of the throttle is normal, but the brakes are controlled from the lead locomotive. An emergency air brake application may be made, however, from the automatic brake valve of the second unit. Also, the brakes on this unit may be released by depressing the independent brake valve handle while it is in the release position.

## OPERATION IN HELPER SERVICE

Basically, there is no difference in the instructions for operating the SD45 locomotive as a helper or with a helper. In most instances it is desirable to get over a grade in the shortest possible time. Thus, wherever possible, operation on the grades should be in the full throttle position. The throttle can be reduced, however, in instances where excessive wheel slips are occurring. For proper traction motor cooling, the locomotive should never be operated on grades below the 5th throttle position.

## ISOLATING A UNIT

When the occasion arises where it becomes advisable to isolate a locomotive unit, observe the following:

1. When operating under power, a unit may be isolated at any time, but discretion as to timing and necessity should be used.

2. When operating in dynamic braking, it is important to get out of dynamic braking before attempting to isolate the unit. This is done by reducing the braking

lever (throttle) to IDLE. The isolation switch can then be moved to START position to eliminate the braking on that unit. If the braking is resumed, other units will function normally. If field loop control of dynamic brakes is being used, do not change position of the unit selector switch.

## CHANGING OPERATING ENDS

When the locomotive consist includes two or more units with operating controls, the following procedure is recommended in changing from one operating end to the opposite end on locomotives equipped with 26L brakes.

ON END BEING CUT OUT

1. Move the automatic brake valve handle to service position and make a 20 pound reduction.
2. After brake pipe exhaust stops, place cutoff valve in CUT OUT position by pushing dial indicator handle in and turning to the desired position.
3. Place independent brake in fully released position.
4. Place MU valve in the desired TRAIL position, depending on brake equipment on trailing units. (MU valve is located in the left hand side of the air pedestal. Push dial indicator inward and turn to desired position.)
5. Position automatic brake valve in handle off position. (Handle may be removed if so equipped.)
6. Place selector lever in OFF position.
7. Place reverse lever in neutral position and remove to lock controller.





8. At the controller, place all switches in the OFF position. Be absolutely certain that the control and fuel pump switch, generator field switch, and engine run switch are in the OFF position.
9. At the engine control panel, place headlight control switch in proper position for trailing unit operation. Place other switches ON as needed.
10. At the circuit breaker panel, the control circuit breaker and the local control circuit breaker remain in the ON position.

NOTE: If the local control circuit breaker is inadvertently placed OFF at this time, the engine will shut down when the trainlined control circuit is re-established. However, the engine may be restarted in the normal manner after placing the local control circuit breaker ON.

11. After completing the operations outlined in the preceding steps, move to the cab of the new lead unit.

ON END BEING CUT IN

1. At the controller, make certain throttle lever is in IDLE, selector lever is in OFF, and the generator field switch is OFF.
2. Insert reverse lever and leave in neutral position.
3. Insert automatic brake valve handle (if removed) and place in SUPPRESSION position to nullify any safety control, overspeed, or train control used.
4. Insert independent brake valve handle (if removed) and move handle to full independent application position.

5. Position cutoff valve in either FRGT or PASS position depending on make up of the train.

6. Place MU valve in LEAD position.

7. At the circuit breaker panel, check that the control circuit breaker is in the ON position. Other circuit breakers remain ON.

8. At the engine control panel, place the headlight control switch in proper position, and other switches on as needed. If the unit selector switch is used it must be properly positioned.

9. At the controller, place the engine run, control and fuel pump, and generator field switch in ON position. Other switches may be placed ON as needed.

## STOPPING ENGINE

There are six ways to stop the engine.

1. Press the emergency fuel cutoff and engine stop button on the engine control panel.

   When the locomotive is standing still or under power, the isolation switch should be placed in STOP position. The stop button can then be pressed in to stop the engine. Since the reaction of the stop button is instantaneous, it need not be held in.

2. Press emergency fuel cutoff button.

   Emergency fuel cutoff pushbuttons are located near each fuel filler opening. These pushbuttons operate in the same manner as the button on the engine control panel and need not be held in nor reset.







3. Use layshaft lever.

   The layshaft lever at the accessory end of the engine can be operated to override the engine governor and move the injector racks to the no fuel position.

4. Close the low water detector test cock.

   When the low water detector trips, oil is dumped from the governor low oil shutdown device, stopping the engine.

5. Use throttle lever.

   To stop all engines "on the line" in a consist simultaneously from the cab of the lead unit, move the throttle to the IDLE position, pull the lever out and away from the controller, and move it beyond IDLE to the STOP position.

6. Pull out low oil shutdown rod on the side of the governor.

NOTE: Observe freezing weather precautions whenever an engine is shut down during cold weather.

## SECURING LOCOMOTIVE FOR LAYOVER

1. Place the reverse lever in neutral position and the throttle in IDLE.

2. Place the selector lever in the OFF position and remove the reverse lever from controller.

3. Place isolation switch in START and press stop button IN.

4. Place all switches on the controller panel in the OFF position (down).

5. Place all circuit breakers and switches on the circuit breaker panel and the engine control panel in the OFF position and open all knife switches.

NOTE: Main battery switch and turbo lube oil pump circuit breaker must remain on for 35 minutes after load operation at throttle No. 3 or above.

6. Apply hand brake and block wheels, if necessary.

7. Cover exhaust stack if there is danger of a severe rain.

8. Drain or otherwise protect engine and cab heaters if there is danger of freezing. See Fig. 3-6.

## TOWING LOCOMOTIVE IN TRAIN

When a locomotive unit equipped with 26L air brakes is placed within a train consist to be towed, its control and air brake equipment should be set as follows:

1. Drain all air from main reservoirs and air brake equipment unless engine is to remain idling.
2. Place the MU valve in DEAD position.
3. Place cutoff valve in CUT OUT position.
4. Place independent brake valve handle in release position.
5. Place automatic brake valve handle in handle off position.
6. Cut in dead engine feature by turning cutout cock, Fig. 2-10, to open (90° to pipe) position. Dead engine cock is located beneath cab floor and may be reached through an access door at side of locomotive.





CAUTION: The pressure regulator shown in Fig. 2-10 is adjusted at a maintenance point in accordance with the type of brake equipment used. The locomotive operator should not attempt to adjust braking pressure.

7. If engine is to remain IDLING, switches should be positioned as follows:
   a. Isolation switch in START position.
   b. All knife switches CLOSED.
   c. Local control and control circuit breakers ON.
   d. Generator field and starting fuses should be removed. Other fuses should be left in place.
   e. Control and fuel pump switch ON.
   f. Fuel pump circuit breaker ON.
   g. Throttle in IDLE, selector in OFF, reverse lever in NEUTRAL. REMOVE REVERSE LEVER FROM CONTROLLER to lock controls.
8. If locomotive is to be towed DEAD in a train, switches should be positioned as follows:
   a. All knife switches OPEN.
   b. All circuit breakers OFF.
   c. All control switches OFF.
   d. Starting fuse removed.
   e. Throttle should be in IDLE, selector in OFF. REVERSE LEVER SHOULD BE REMOVED FROM CONTROLLER.

NOTE: If there is danger of freezing, the engine cooling system should be drained. See Fig. 3-6.

## FREEZING WEATHER PRECAUTIONS

As long as the diesel engine is running, the cooling system will be kept adequately warm regardless of ambient (outside) temperatures encountered. It is only when the engine is shut down or stops for any reason that the cooling system requires protection against freezing.

In instances where danger of freezing is present, the cooling system should be completely drained or have steam admitted. The draining procedure is as follows:

1. Remove the filler cap.

2. Open the drain and heater supply valves located at the floor in front of the engine, Fig. 3-6. This will drain the engine, radiators, water tank, oil cooler, air compressor, and heaters.

## REMOTE TRACTION MOTOR CUTOUT SWITCH

On locomotives equipped with remote panel mounted traction motor cutout switches, the panel instructions adjacent to the switch must be followed exactly when a traction motor is to be cut out. The cutout switch can not be turned unless the unit is isolated and the local control circuit breaker is closed.



# SECTION 4

# TROUBLE SHOOTING

## INTRODUCTION

This section is devoted to operational problems that may be encountered on the road and the steps that can be taken to determine their cause and to make necessary corrections. No attempt is made to provide detailed explanations of the equipment functions concerned.

Troubles occurring on the road and the resulting delays can be minimized through proper locomotive inspection, maintenance and operation. When operating problems do occur, however, it is important that they be quickly eliminated. Towards that end, a good, thorough understanding of locomotive equipment function is helpful. This basic knowledge, together with the suggestions given in this section should provide the necessary means for achieving the "on time" performance desired.

## GENERAL PROCEDURE

Safety devices automatically protect the equipment in case of faulty operation of almost any component. In general this protection is obtained by unloading or preventing the loading of the diesel engine, with a resulting loss of locomotive pulling power. In most instances, the diesel engine speed will be reduced to idle.

Operating difficulties are usually indicated by the ringing of an alarm bell and the lighting of one or more signal lights. The alarm circuit is arranged so that the bells will ring in all units of a multiple unit consist, but the signal light will be on only in the unit experiencing the trouble. With this arrangement the unit in trouble can be quickly detected.

ALARM BELL RINGS — NO SIGNAL LIGHTS ON IN LEAD UNIT

Cause - Fault in trailing unit or an AR10 overvoltage condition in the lead unit.

Effect - 1. Lead unit operates normally, but loss of power is evident. Cause of alarm is in a trailing unit.

a. High voltage circuit ground or fault condition.

b. Fault in AR10 excitation circuitry.

c. Engine shutdown.

2. Lead unit operates normally and no loss of power evident. Trailing unit hot engine.

3. Intermittent alarm signal and loss of power on lead unit. AR10 overvoltage condition. Operation may continue, but unit should be isolated when practical.

Correction - 1. If lead unit is operating normally, but loss of power is evident, wait for 10 seconds after alarm sounds, then press the remote ground reset button (if so equipped). It is not necessary to isolate





units or return throttle to idle before pressing the remote reset pushbutton.

If alarm is silenced, a trailing unit ground relay has been reset. If the remote ground reset button does not silence the alarm, the fault must be determined in the affected unit.

2. Cause of trailing unit hot engine must be determined in the affected unit.

3. If intermittent alarm signal and loss of power is in the lead unit, the lead unit should be isolated when practical.

## ALARM SIGNAL LIGHTS

Colored alarm signal lights are located on the engine control panel on the rear cab wall. Additional white signal lights are located on the locomotive controller.

RED — HOT ENGINE

Cause - Excessive engine cooling water temperature.

Effect - Alarm bells ring in all units. Engine speed and power remain normal.

Correction - To silence the alarms and extinguish the light, it will be necessary to reduce engine cooling water temperature.

1. Isolate unit and allow engine to run at idle.
2. Check water tank to see if there is sufficient water in system.
3. Check to see if cooling fans are running.
4. Shutters should be open. If closed, check position of shutoff valve in air supply line.

BLUE — NO POWER

Cause - D14 alternator failure; thus, no AC auxiliary power is being generated, NVR drops out and excitation is removed from the main generator. May be due to loss of D14 alternator excitation or electrical difficulty in the system (true failure). May also be caused by the diesel engine stopping for any reason while on the line (false failure).

Effect - Alarm bells ring in all units. If the failure was due to electrical fault, the engine in the unit concerned will go to idle speed.

Correction - To silence alarms, isolate unit. Method of correction depends upon whether failure was due to electrical or mechanical fault.

A. Engine Stopped (not D14 failure)

1. Engine overspeed device tripped. Check lever position, reset if necessary.





2. Low water or crankcase (oil pan) pressure detector tripped. The amber low oil light will also be on in such case.
3. Engine starving for fuel. Observe for proper fuel flow through return sight glass by operating fuel pump. If fuel is not evident, check reasons given in this section under "Insufficient Fuel."
4. Throttle lever in STOP position.
5. Low oil pressure. Amber low oil light will be on in such case.
6. FPC de-energized (engine stops immediately).

B. D14 Failure (engine idling)

1. Blown 60-ampere alternator field fuse.
2. Blown auxiliary generator fuse.
3. Blown 30-ampere auxiliary generator field fuse.

AMBER — LOW OIL/LOW WATER/CRANKCASE PRESSURE

Cause - Low oil pressure or high oil suction in the diesel engine lubricating system or low oil pressure to the turbocharger. May be due to insufficient oil, excessively hot oil, diluted oil, or clogged strainers.

A low oil pressure indication is also given when the crankcase pressure / low water detecting device is tripped. This is because the device dumps oil from the low oil pressure detector in the engine governor.

Effect - The diesel engine in the unit concerned will be stopped and the yellow light on the engine control panel will be on. The push-button on the governor will be out, with the red indicating band exposed. The blue NO POWER light will also come on as NVR drops out due to no D14 voltage.

Correction - The following steps should be taken to correct or determine cause of difficulty.

1. Isolate unit to stop alarm bells.

2. Reset governor trip button. Amber light will go out.

3. Check engine lubricating oil level using dipstick. Oil should be near FULL mark.

4. Observe for external oil leakage from broken pipes.

5. Check the low water and crankcase (oil pan) pressure detecting device mounted on the engine. If the lower button protrudes, the failure is due to low water. If the upper button protrudes, the failure is due to excessive oil pan pressure.

Upper Button Protrudes

Cause - Oil pan pressure exceeds a predetermined positive pressure setting. May be the result of gases entering the oil pan through cracked pistons, badly worn rings, broken rings, or due to a dirty oil separator.

Effect - Engine shut down





Correction - Manually reset the device by holding the button in for 5 seconds. Proceed with the checks shown for low oil shutdown.

Lower Button Protrudes

Cause - Low water level, sudden loss of engine water, or low water pressure at engine start.

Effect - Engine shuts down. If water level is only slightly low, the engine may shut down only at high throttle positions.

Correction - Check for water leaks. Add water. Reset governor low oil trip plunger. Press detector reset button and hold for 5 seconds immediately after restarting engine.

6. Check that lubricating oil viscosity is not reduced due to dilution with fuel oil.

7. Check that oil viscosity is not reduced due to excessive heat. In such case the hot engine alarm may also be activated.

8. Restart engine after reset buttons have been pressed and corrective action taken. Observe oil pressure on gauge. It should be a minimum of 9 psi with engine at idle.

CAUTION: In the event of continued low oil pressure, high suction or low water, the governor trip button will again move to stop the engine. The engine should not be repeatedly started or forced to run when the governor keeps shutting down the engine. The engine should NEVER be manually operated by using the layshaft lever to take control away from the governor when the governor persists in stopping the engine.

WHITE - H.V. GRD/FAULT

Cause - Insulation failure, presence of water, traction motor flashover, or a group of five diodes failed in the main generator.

Effect - The light comes on when the ground relay trips. Engine speed will be reduced to idle, power is lost, and the alarm bell rings.

Correction - Wait 10 seconds, then press the ground reset button. The light will go off and power will be restored smoothly. Engine speed will return to that called for by throttle position.

WARNING: When the alarm rings for the third time after using the reset button twice, the affected unit should be isolated. Do not isolate the unit and allow it to remain in a consist unless it is absolutely certain that all wheels are able to rotate freely.





GREEN - EXCITATION LIMIT

Cause - Tripped excitation limit relay due to excessive generator field current. May be caused by a defective excitation circuit or a defective rate control panel.

Momentary pickup of the relay may sometimes occur when the throttle is advanced rapidly during high speed operation.

The excitation limit relay may also trip if the backward transition relay fails to operate properly or if shunting contactors fail to operate properly.

Effect - Excitation limit relay pickup modulates locomotive power. If the condition is not automatically corrected, a timing relay picks up to turn on the light, drop out the generator field contactor, and latch in the excitation limit circuit.

Correction - No action is needed for momentary excitation relay pickup; however, if the fault persists and the light locks on after 20 seconds, return throttle to idle position or isolate the unit to stop the alarm and drop out the excitation limit relays. If the excitation limit light again locks on after the unit is placed on the line and power is restored, isolate the unit.

WHITE — TURBOCHARGER AUX. PUMP

This is not an indication of a fault. It merely provides an indication that the auxiliary pump is delivering oil to the turbocharger bearings. When the light is on after load operation at throttle position No. 3 or higher, the main battery switch should remain closed.

WHITE - WHEEL SLIP

Cause - Severe wheel slip causes the wheel slip light to come on. Minor and moderate slipping does not cause the light to come on.

Effect - Minor slips are corrected by instantaneous power reduction. Moderate slips bring about a greater reduction of power in addition to a timed application of sand. Severe slipping causes the wheel slip light to come on.

Correction - Corrective action is automatic. The throttle should be reduced only if severe lurching threatens to break the train.

WARNING: A unit experiencing repeated and persistent wheel slip action should not be isolated and allowed to remain in the locomotive consist unless inspection reveals that all wheels are capable of rotating freely.





WHITE — PCS OPEN

Cause - Tripping of the PCS switch due to safety control "penalty" or emergency air brake application.

Effect - The speed and power of ALL engines in the locomotive consist are reduced to IDLE conditions. No alarm bells will ring.

Correction - The PCS switch is automatically reset, provided that:

1. Throttle is placed in IDLE.
2. Cause of difficulty (safety control pedal, locomotive overspeed, train control) is eliminated.
3. Air brake is recovered. This is done by moving the automatic brake valve handle to the suppression position (26L) and allowing it to remain there until the application valve resets. This ordinarily takes 6 to 10 seconds. The PCS OPEN light will then go out.
4. Return brake valve handle to running position.

NOTE: In the event of the PCS switch tripping due to an emergency air brake application initiated from the locomotive, the brake valve should be returned to release position after the locomotive stops. The PCS switch will reset automatically and the light will go out if the throttle is placed in IDLE. If emergency brake is applied due to train action (conductor's valve or break-in-two), it is suggested that after the train stops, the automatic brake valve be placed in emergency position and

left there until cause of application has been corrected. After this, place brake valve in running position and the throttle in IDLE to reset PCS switch.

WHITE — BRAKE WARNING (If Used)

Cause - Excessive dynamic braking strength, defective brake warning circuit, or reverse lever improperly positioned.

Effect - No noticeable effect if braking current is too high. Equipment damage is possible if light is allowed to cycle on and off for longer than three seconds.

No braking obtainable if light comes on due to defective brake warning circuit or improperly positioned reverse lever.

Correction - Excess braking current is usually quickly and automatically corrected by the dynamic brake regulator. In the event the warning light blinks excessively, the throttle should be moved to reduce braking strength. The light should never be allowed to blink on and off more than three seconds.

## CORRECTION OF OPERATING DIFFICULTIES

INSUFFICIENT FUEL

Insufficient fuel will cause erratic engine operation. Lack of fuel will cause engine to shut down. It will also prevent an engine from being started.





Condition of the fuel system may be determined by observing the two sight glasses mounted on top of the filter assembly located at the right front of the engine. The glass closer to the engine should be full whenever the fuel pump and engine are running. The other adjacent glass should always be empty.

FOR FUEL PUMP TO OPERATE

1. Main battery switch must be closed (during prime).
2. Control and local control circuit breakers must be ON.
3. Control and fuel pump switch must be ON.
4. Fuel pump 15-ampere circuit breaker must be ON.
5. Cable must be firmly connected to motor.
6. FPC and FPR coils must be energized.
7. Auxiliary generator must be developing power.

NO FUEL WITH PUMP RUNNING

1. Lack of fuel in tank.
2. Slipping or broken coupling between motor and pump.
3. Suction leak in piping.
4. Clogged suction or discharge filters.

ENGINE CANNOT BE STARTED

Engine starting difficulties fall into two categories; namely, engine does not rotate in START position, or

engine rotates but does not start. The following items should be checked in either event.

Engine Does Not Rotate

1. Main battery switch must be closed.
2. Isolation switch must be in START position.
3. Starting 400-ampere fuse must be good and in place.
4. Control and local control circuit breakers must be closed.
5. Control and fuel pump switch must be in ON position.
6. GS and GSA contactors must pick up.
7. Both cranking motor pinions must mesh.
8. Engine must not contain hydraulically locked cylinder. On units equipped with reduced voltage initial cranking, further cranking attempts may be made after the cranking motors are allowed to cool, but discretion must be used when repeated attempts are made. Always report stalled cranking attempts to proper maintenance personnel.

Engine Rotates But Does Not Start

1. Engine overspeed trip lever must be set.
2. Low oil pressure button in governor must be in.
3. Fuel system must be sufficiently primed, and layshaft lever must be positioned at about 1/3 rack.
4. Local control circuit breaker must be in ON position.
5. Governor shutdown solenoid DV must be de-energized.







ENGINE STOPS SOON AFTER STARTING

1. Fuel pump circuit breaker must remain closed.
2. Control and local control circuit breakers must remain closed.
3. Low water and crankcase (oilpan) pressure detector buttons must be set.

ENGINE DOES NOT RESPOND TO THROTTLE

In instances where an engine is running normally at idle speed but does not speed up when throttle is advanced, the indication is that the governor speed control solenoids AV, BV and CV are not receiving power. Generally, this condition would be due to the ER relay being de-energized. The following items should be checked:

1. Ground and fault relays must be set.
2. NVR must be energized.
3. Isolation switch must be in RUN.
4. PCS switch must be set.
5. Engine run switch must be ON.
6. Control circuit breaker and control and fuel pump switch must be in ON position. In addition to lack of throttle response with these devices OFF, the engine will in a few minutes shut down from lack of fuel.
7. Backward transition relay not functioning properly.
8. Excitation limit and overvoltage relays not functioning properly.

LOCOMOTIVE DOES NOT LOAD UP

In instances where the diesel engine is running and responds properly to throttle but the locomotive does not load up, the following points should be checked:

1. Reverse lever must be in either forward or reverse.
2. Selector lever must be in power-No. 1 position.
3. Generator field switch must be ON.
4. Generator field fuses must be good and in place.
5. Power contactors must pick up.
6. Generator field contactor must pick up and overriding solenoid must be de-energized.
7. Brake warning light must not come on when selector lever is placed in brake position.

ENGINE GOES TO IDLE DURING OPERATION

See possible causes in preceding article entitled "Engine Does Not Respond To Throttle."

ENGINE STOPS DURING OPERATION

In instances where a diesel engine stops during normal operation, the following items may be responsible.

1. Engine overspeed trip may have occurred.
2. Low oil button on governor may be out.
3. Crankcase (oil pan) pressure / low water detector tripped.





4. Insufficient or lack of fuel. See preceding fuel system difficulties.
5. Auxiliary generator fuse may have opened.
6. FPC de-energized.

BATTERY CHARGING METER SHOWS DISCHARGE

With the diesel engine running, the auxiliary generator should provide all low voltage current needs. The battery charging ammeter should read either zero or charge. If it continually reads discharge, the following should be checked.

1. Auxiliary generator fuse must be good and in place.

NOTE: A strong discharge reading at engine stop, followed by a burned out auxiliary generator fuse, indicates a shorted battery charging rectifier.

2. Auxiliary generator field fuse (30-ampere) must be good and in place.
3. Voltage regulator must be operative and properly adjusted.

## UNUSUAL OPERATING PROBLEMS

In the majority of instances, the various safety devices will function in the event of trouble to safeguard the equipment by unloading the engine, or causing it to go to idle or stop. There are instances however, when such action is not automatically taken and it may be advisable to take manual action. Since these occasions are unusual, each should be handled individually, using good judgment. The following suggestions may be helpful.

Mechanical Problems

1. Smoke Coming Out Of Exhaust - Operation may continue.
2. Oil Or Fire Coming Out Of Exhaust - Stop engine.
3. Smoke In Engineroom Coming From Engine - Stop engine, DO NOT REMOVE ANY INSPECTION COVERS.
4. Governor Low Oil Button Trips Repeatedly - This may be due to low oil, positive crankcase pressure, or low water pressure. If the shutdown is due to low oil or positive crankcase pressure do not restart the engine. If shutdown is due to low water, it may be possible to operate the engine at reduced throttle if the low water reset button on the crankcase pressure/ low water detector stays in when pressed after engine is restarted.
5. Unusual Noises - Investigate source. Stop engine or discontinue operation to prevent damage if noise is pronounced.
6. Engine Cylinder Test Valve Leaking - Do not allow engine to operate with leaking or blowing valve.
7. Safety Valves Popping On Air Compressor Intercooler Or Main Reservoir - Continue operation.
8. Engine Overspeed Trip Stops Engine Repeatedly - Leave engine stopped.

Electrical Problems

1. Ground Relay Tripped Light Comes On Repeatedly - Isolate unit after three indications. Stop locomotive and check to see that all wheel can rotate freely.





2. Continued Wheel Slip Indication - Isolate unit; Stop locomotive and check to see that all wheels can rotate freely.
3. Loss of power is evident, but no alarm indication is given and the reason for the difficulty can not be determined. Operation may continue, but the condition should be reported to proper maintenance authority.

CAUTION: Excitation of the main generator for test purposes without load or lightly loaded should be restricted to an absolute minimum.